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ABSTRACT

Designed to provide the basic knowledge and hands-on skills necessary to prepare job-ready machinist trainees, these instructional materials focus on the following areas of trade and industrial education: orientation, basic and related technology, hand and bench work, and power saws and drilling machines. Suitable for use in secondary, postsecondary, or adult education classes, these materials are competency based in that the objectives of each unit are measurable to a minimum standard of acceptance. A total of 14 units are included in the four sections. Covered in the units are machine trades orientation, general shop safety, basic math, blueprints, rules, micrometer measuring tools, vernier measuring tools, materials and cutting fluids, hand tools, pedestal grinders, power saws, and drill presses. Each unit includes the following components: performance objectives, suggested activities, information sheets, transparency masters, assignment sheets, job sheets, tests, and answers to tests and assignment sheets. (MN)

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ED212879

Machine Shop I

Written by
James Dunn, Trade and Industrial Curriculum Specialist
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Stillwater, Oklahoma

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For the Division of Trade and Industrial Education
Ivan Armstrong, State Supervisor
OKLAHOMA STATE BOARD OF VOCATIONAL AND TECHNICAL EDUCATION
Leslie Fisher, Chairman
Francis T. Tuttle, Director
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1981

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FOREWORD

We believe that the most effective way to improve vocational education is through the development and use of sound instructional materials. *Machine Shop I* is designed to provide the basic knowledge and hands-on skills to prepare job-ready machinist trainees. This publication focuses on the following areas: Orientation, Safety, Math, Blueprint Reading, Measuring and Measurements, Bench and Hand Tools, Power Saws, and Drilling Machines.

In Oklahoma, our vocational machine shop programs are designed for two academic school years of approximately 1,050 hours of training. We feel that this material represents the theoretical aspect of the subject as well as practical application. The theoretical aspect of the curriculum should provide the background knowledge necessary for students to make judgments regarding the procedures they are expected to perform.

James Dunn brings over ten years industrial experience and twelve years vocational teaching experience to the writing of this manual. We are especially proud of the intense involvement and support of industry personnel who assisted James Dunn in the writing of this curriculum. This input is the key to designing and writing a curriculum that teaches the skills needed by industry.

We believe strongly that *Machine Shop I* will help machine shop instructors to improve their programs. As instructors "bring to life" the contents in the vocational setting, the student is sure to become "job-ready" for the occupation of machinist.

Francis T. Tuttle, State Director
Department of Vocational and Technical Education

Ivan Armstrong, State Supervisor
Trade and Industrial Education

PREFACE

The purpose of *Machine Shop I* is to equip students with basic knowledge and skills that will enable them to enter the machine trade. This volume also gives the learner a good foundation for Machine Shop II and III.

The assignment sheets and job sheets are the chief strengths of this volume. They are directly related to the lesson and provide for appropriate practice with pencil and paper and actual hands-on jobs using the machinery of the trade. The material is competency based in that the objectives of each unit are measurable to a minimum standard of acceptance.

This curriculum has been put together so it can be used in full-time secondary and post-secondary classes, as well as part-time adult classes. It also can be adapted to open entry-open exit programs so each student can progress at his or her own pace.

Machine Shop I is self-contained (not designed to be supplemented by a textbook) and should take the place of using three or four textbooks. The subject material is not in the order of instruction. It is recommended that the user package this volume by units and arrange them to fit the way in which the instructor teaches. All or part of a unit may be taught at a given time.

A skilled instructor who can supplement, personalize, and localize this material will go a long way toward helping the learner to advance in the machine trade, which is changing at a fantastic rate. These changes have created a great demand for workers with job-ready skills. Mastering machine skills will enable the learner to enter a growing field where one can take pride in working with one's hands.

James Dunn, Trade and Industrial
Curriculum Specialist

ACKNOWLEDGMENTS

Planning and Reviewing Committee

I am indeed grateful for the generous contribution of time, expertise, and cooperation given by committee members and the schools or industries they represent.

Special thanks to Mercury Marine, Kobe, Inc., and Halliburton Services for releasing employees to serve on the committee. This Machine Shop publication would not have become a reality without the combined efforts of the following:

Larry Crow--Kobe, Inc., Oklahoma City, Oklahoma
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Wesley Taylor--Caddo-Kiowa AVTS, Fort Cobb, Oklahoma
Ken Hulsizer–Indian Meridian AVTS, Stillwater, Oklahoma
Eldon Richey–O.T. Autry AVTS, Enid, Oklahoma
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Kenneth Morgan--Halliburton Services, Duncan, Oklahoma
Bill Whitmore--St. Brian Valley Career Center, Longmont, Colorado
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James Hilton--Krump, Tennessee
Sammie Smith--Krump, Tennessee
Bill Hill--State Department of Vocational and Technical Education, Stillwater, Oklahoma

Special thanks to Ken Robb, Tulsa AVTS at Memorial, for his assistance in proofing final copies of this manual.

I would also like to express my appreciation to the following companies for waiving copyright and supplying many of the photographs and illustrations used in this manual.

The L.S. Starrett Company
Brown & Sharpe Manufacturing Company
Cincinnati Milacron
Clausing Machine Tools
Hardinge Brothers, Inc.
Kalamazoo Saw Division, KTS Industries

A special thanks to Ken Hulsizer, Machine Shop Instructor, and the administrative staff at Indian Meridian AVTS, Stillwater, Oklahoma, for the use of their facilities and cooperation in obtaining photographs for this publication.

Deep appreciation is expressed to my co-workers. First, to Joyce Sawatzky who patiently trained and assisted me during the development of this curriculum. Her enthusiastic leadership, creative ability, and guidance are beyond words. Second, to Lynne Murnane for her expertise and dedication in the editing of this material. And, to Sarah Mussett for her role in the editing process. Another "thanks" to Greg Pierce for coordinating this manual through the print shop. Sincere appreciation is extended to Bob Patton for giving me the opportunity to write this curriculum and for his superior leadership during the development and publication of this manual.

Another special thanks goes to Dana Cole and Joan Henderson for the excellent job they did taking and processing many of the photographs in this manual.

Special recognition goes to staff members from the Curriculum and Instructional Materials Center and the Graphics Division of the State Department of Vocational and Technical Education for their services offered during the development and publication of *Machine Shop I*.

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USE OF THIS PUBLICATION

Instructional Units

Machine Shop I includes four sections and fourteen instructional units. A standard format was established in 1970 for the development of instructional materials for all Oklahoma vocational teachers. This format includes eight basic components which form a unit of instruction: performance objectives, suggested activities for the teacher, information sheets, assignment sheets, job sheets, transparency masters, tests, and answers to tests and assignment sheets. Depending on the specific objectives, transparency masters, assignment sheets, and job sheets may or may not be included in the unit of instruction.

All of the unit components "zero in" on measurable and observable learning outcomes. Teachers are encouraged to supplement, personalize, localize, and motivate with these materials in order to develop a complete teaching-learning process.

Units of instruction are designed for use in more than one lesson or class period of instruction. Careful study of each unit of instruction by the teacher will help him or her determine the following

A. Amount of material that can be covered in each class period
B. Skills which must be demonstrated
  1. Supplies and equipment needed
  2. Amount of practice needed
  3. Amount of class time needed for demonstrations
C. Supplementary materials, such as pamphlets and filmstrips, that must be ordered
D. Resource people who must be contacted

Performance Objectives (white pages)

Each unit of instruction is based on the performance needed for successful employment in an occupational area. Performance objectives are stated in two forms: unit objectives, stating the subject matter to be covered in a unit of instruction, and specific objectives, stating the student performance necessary to reach the unit objective.

Since the objectives of the unit provide direction for the teaching-learning process, it is important that teachers and students have a common understanding of the intent of the objectives. Following is a list of performance terms, their meanings, and behavioral synonyms which may have been used in this material.

A. Name--The individual supplies a name for objects, events, or people

Behavioral synonyms: Label, list, letter, record, reiterate, repeat, write

B. Identify--The individual selects a named, described, or pictured object by pointing to it, touching it, picking it up, or selecting it

Behavioral synonyms: Select, mark, match, choose, judge

C. State a rule--The individual communicates a relationship or principle which could be used to solve problems or perform a task

D. Apply a rule--The individual supplies an answer to a problem by using a stated relationship or principle

Behavioral synonyms: Solve, calculate

E. Describe--The individual relates sufficient characteristics or properties of an object or event so that a second individual will be able to state what is being discussed

Behavioral synonyms: Define, discuss, interpret, recite, tell how, tell what happens when

F. Distinguish--The individual selects an object or event from two or more which are easily confused

Behavioral synonyms: Discriminate, differentiate

G. Order--The individual arranges three or more objects or events in a sequence based on a stated property

Behavioral synonyms: Arrange, sequence, list in order, classify, divide, isolate, sort

H. Construct--The individual makes a physical object, a verbal statement, or a drawing

(NOTE: Construct is used when the finished product or result is important.)

Behavioral synonyms: Draw, make, build, design, formulate, reproduce, transcribe, convert, put together, compile

I. Demonstrate--The individual performs several operations necessary to carry out a specified process

(NOTE: *Demonstrate* is used when it is desirable to watch the student perform a task, one of the highest levels of student performance.)

Behavioral synonyms: Show your work, show procedure, perform an experiment, perform the steps, operate, remove, replace, turn off/on, (dis) assemble, (dis) connect

The objectives should be provided for students and stressed throughout the teaching-learning process. This will help answer any questions concerning performance requirements for each instructional unit. The objectives can also help determine teaching strategies and instructional methods. Prepare for each unit by deciding how each objective can best be taught.

The objective sheet may be also used as a quick pretest to determine prior knowledge of students and to determine whether further study or activities are necessary. Teachers should feel free to modify, delete, or add objectives in order to meet the needs of the students and community. When changes in objectives are made, the teacher should remember to supply the needed information, assignment and/or job sheets, and criterion test items.

Suggested Activities (pink pages)

This component is included only in teacher material. The suggested activities page assists teachers during the preparation stage of the teaching-learning process by providing suggestions for delivery and/or presentation during the instructional process. Read the suggested activities before teaching the units so that supplemental materials can be obtained, audiovisual materials prepared, and outside resources contacted. Duties of the teacher will vary according to the particular unit.

The references that are listed are ones used in the development of each unit. They should be used by the teacher to supplement knowledge of the subject area or to help students with particular interests or occupational objectives in the area covered.

Information Sheet (green pages)

The information sheet provides "must know" content essential for meeting the cognitive (knowledge level) objectives of the unit. The information is written in a topical outline form and is keyed to the specific objectives.

Teachers will find that the information sheet serves as an excellent guide for presenting background knowledge necessary to develop the skills specified in the unit objective. The information sheet may also be used for coordination activities and advisory committees.

Students should read the information sheet before the information is discussed in class. Space is provided in margins for students and teachers to add notes that supplement, localize, personalize, or provide motivation for each unit.

Transparency Masters (white pages in teacher material and green in student material)

Transparency masters provide information in a special way. The students may see as well as hear the material being presented, thus reinforcing the learning process. Transparencies may present new information or they may reinforce information presented in the information sheet. They are particularly effective when identification is necessary.

Transparencies should be made and placed in the notebook where they will be immediately available for use. Transparencies direct the class's attention to the topic of discussion. It is recommended that teachers stand away from the overhead projector when discussing transparency material to avoid speaking too loudly.

Assignment Sheets (brown pages)

Assignment sheets give students a chance at problem solving, self-assessment, and/or practical experience with the information. They assist students in the application of knowledges which are necessary prerequisites to skill development. These may be given to the student for completion in class or used for homework assignments. Answer sheets are provided, when appropriate, and can be used by the student and/or teacher for checking student progress.

Job Sheets (blue pages)

Job sheets are another important segment of a unit of instruction. The job sheets provide a list of equipment, tools, and materials needed to complete a manipulative or psychomotor skill. They describe a step-by-step procedure needed to complete each task or job. Diagrams, photographs, and illustrations are provided to assist students in achieving the skill.

A teacher should demonstrate to students the procedures outlined in each job sheet. Furthermore, the teacher needs to localize the job sheet accordingly to the equipment and supplies available in the local lab or shop situation. Job sheets also furnish potential employers with a picture of the skills being taught and the performances they might reasonably expect from a person who has had this vocational instruction.

Tests (yellow pages)

This component provides criterion-referenced evaluation of every objective listed in the unit of instruction. It is crucial to note that both paper/pencil and performance objectives must be evaluated.

The tests may be written or oral. It is recommended that the tests be divided into shorter tests covering three or four objectives at a time and given soon after those objectives have been covered. A selection of questions from the units covered may be used for final tests at the end of each term if desired. If objectives have been added, deleted, or modified, be sure to make the changes on the test.

The acceptable response on a unit test--eighty-five percent in most units--may be raised or lowered to fit the topic or students' ability levels. The percentage applies to the overall score, not to each question. The final unit grade should be obtained by using the paper/pencil score along with teacher evaluations of student demonstrations of the desired skills.

Answers to Test and Assignment Sheets (pink pages)

These components are designed to assist the teacher in evaluation of student performances.

Page Numbering

Each publication from the Curriculum and Instructional Materials Center is assigned a specific abbreviation. For example, *Machine Shop I* has been abbreviated MS I. The units are then numbered consecutively within each section. An example of a page number is MS I - 1-A. Because CIMC publications are loose-leaf, this system of page numbering was adopted so that pages from different manuals would not get mixed up.

Methods of Disseminating Material

Material may be given out a unit or page at a time to keep the material before the students always new. Some teachers ask students to furnish a three-ring binder for the units while studying a particular unit. This is more convenient for taking the materials home to study. Each unit is then placed in the larger binders upon its completion. The large binders may be purchased at cost from the CIMC. Some teachers have stored the materials by units in filing cabinets or boxes until needed for use. All the units may be given out at once if desired.

Student materials should be provided for each student for best results. Student materials contain everything but the test answers, answers to assignment sheets, and suggested activities. The tests are collated at the back of student material and should be removed and stored until needed. Students should be allowed to take their materials home at the end of the year.

Teaching Methods

It is a challenge to keep students motivated. Supplement the objectives by providing the "why," personal experiences, and current information. Prepare for each unit by deciding how each objective can best be taught. Allow students to become involved in preparing and planning.

MACHINE TRADES ORIENTATION
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to evaluate the occupational outlook, places of employment, and personal traits needed for working in machine trades. The student should also be able to identify basic machines used by a machinist. This knowledge will be shown by completion of assignment sheets and unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to

1. Match job titles associated with machine trades to the correct definitions.
2. Write statements concerning occupational outlook for machine trades workers.
3. Describe personal traits and responsibilities necessary for working in machine trades.
4. Name types of employers of machine trades workers.
5. Identify common types of equipment used in machine trades.
6. State guidelines for completing a job application form.
7. Describe working conditions and job benefits available to machine trades workers.
8. Survey job opportunities for machine trades workers.
9. Interview a machine trades employee.
10. Complete a job application form.

MACHINE TRADES ORIENTATION
UNIT I

SUGGESTED ACTIVITIES

I. Suggested activities for teacher

   A. Provide students with objective sheet.

   B. Provide students with information and assignment sheets.

   C. Discuss unit and specific objectives.

   D. Discuss information and assignment sheets.

   E. If necessary, help student locate worker to interview for Assignment Sheet #2.

   F. Discuss the many types of machine trades jobs available.

   G. Use job application forms completed by student to interview the students.

   H. Obtain *Critical Steps of Job Interviewing* for use with students leaving/completing program.

   (NOTE: This product includes programmed reading exercises, listen-respond exercises, and structured role plays. The kit includes instructor manual, 16 mm film, and six cassettes for a 3 1/2-4 hour training program. *Critical Steps for Job Interviewing* is available for purchase from the Curriculum and Instructional Materials Center, 1515 West Sixth, Stillwater, OK 74074.)

   I. Use materials in VICA unit, "Applying for a Job" to teach preparation of resumés.

   J. Obtain job application forms from local industries for extra practice with students.

   K. Give test.

   L. Reteach if necessary.

II. Instructional materials

   A. Objective sheet

   B. Information sheet

C. Assignment sheets

  1. Assignment Sheet #1--Survey Job Opportunities for Machine Trades Workers

  2. Assignment Sheet #2--Interview a Machine Trades Employee

  3. Assignment Sheet #3--Complete a Job Application Form

D. Test

E. Answers to test

III. Unit reference--*Hart Industrial Supply Company Catalog*. Oklahoma City: Hart Industrial Supply Company, 1977.

MACHINE TRADES ORIENTATION
UNIT I

INFORMATION SHEET

I. Job titles associated with machine trades

A. Machine tool operator--Operates a specific machine; responsible for checking parts, making minor adjustments, and changing tools

(NOTE: In some plants operators are expected to make the initial set-up.)

Examples: Drill press operator, turret lathe operator, screw machine operator

B. Machinist--Is considered capable of making all set-ups and operating any machine in the shop; reads blueprints, plans the job procedures from the blueprint, makes math calculations, and then makes the part

Examples: All-around machinist, general machinist, class A machinist, journeyman machinist

C. Set-up person--Prepares a machine tool for a particular operation or series of operations; work involves mounting and aligning work-holding devices, setting and adjusting cutters, and establishing procedures for operation

(NOTE: This person will usually show the operator how to make and check the part to blueprint specifications.)

D. Layout person--Scribes or draws lines showing shape, size, hole locations, and other information necessary to complete a job; uses both precision and other tools

E. Quality control inspector--Checks parts against dimensions specified on blueprint; may also check surface finish and general appearance of part

(NOTE: This person has the final word in determining if the part can be sold, and if all who have worked on the part have done their job correctly.)

F. Instrument maker--Works from prints, sketches, photographs or parts, and must understand machine parts and how they work; has some basic knowledge of welding and electronics

G. Tool and die maker--Is responsible for making special tools that produce parts; knows materials well and has a high degree of skill

H. Toolroom tender--Is responsible for dispensing special tools, keeping tools sharp and in good working condition

(NOTE: In some plants the toolroom tender takes a plan sheet and makes up tool packages for jobs using precision instruments.)

INFORMATION SHEET

I. Machine specialist--Makes all set-ups; works to a high degree of skill on one particular machine

Examples: Lathe specialist, milling machine specialist, grinding machine specialist, NC and CNC operator

J. Machinist trainee--Has completed a course at a vocational-technical school or worked in a related job; must have basic knowledge and be willing to undergo additional training to become a machinist

K. NC and CNC operator--Is responsible for set-up of machine; periodically inspects parts and tooling for tolerance and finish

(NOTE: NC is an abbreviation used for a numerically controlled machine. CNC is an abbreviation used for computerized numerically controlled machine.)

L. NC programmer--Works from blueprint to plan sequence of operations and writes the program in the machine language so the part can be made; usually present on initial set-up and run of the part

II. Occupational outlook for machine trades workers

A. Machine workers are and will be employed in every state and city in the country

B. Job openings will result from deaths, retirements, transfers to other fields, and advancing technology

C. Rapid rise in consumer demand for machined, formed, and molded products will result in higher employment rates

D. Employment in various machining occupations is expected to increase at different rates

E. Machine trades workers have excellent opportunities for advancement with experience and special training

III. Personal traits and responsibilities necessary for working in machine trades

A. Operate shop equipment correctly

B. Be safety conscious and follow safety regulations

C. Take instructions readily and follow directions

INFORMATION SHEET

D. Show enthusiasm for work

E. Have pride in the trade

F. Be conscious of waste in materials and working hours

G. Be neat and orderly

H. Be punctual

I. Control temper

J. Attend work regularly

K. Perform equipment maintenance

L. Follow company regulations

IV. Types of employers of machine trades workers (Assignment Sheet #1)

(NOTE: When you consider all objects used in today's world that have been made by someone using metal working equipment, you can get an idea how large and varied the machine trades profession is.)

A. Automotive industry

B. Aerospace industry

C. Aircraft industry

D. Farm machinery industry

E. Private industries

F. Maintenance shops

G. Textile industry

H. Paper industry

I. Oil field industries

J. Gas and chemical industries

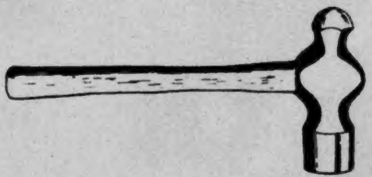
K. Marine industry

INFORMATION SHEET

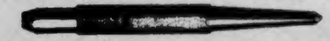
V. Common types of equipment used in machine trades

A. Bench and hand tools

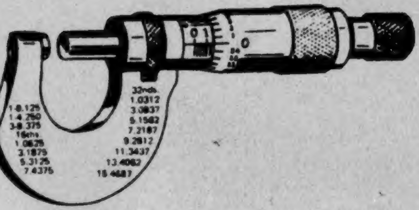
1. Ball peen hammer



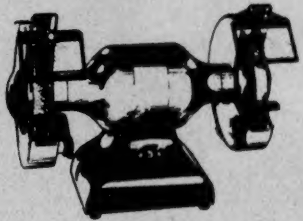
2. Punch



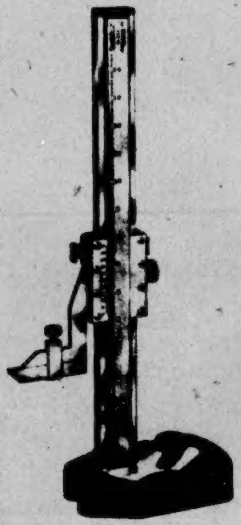
3. Measuring tool



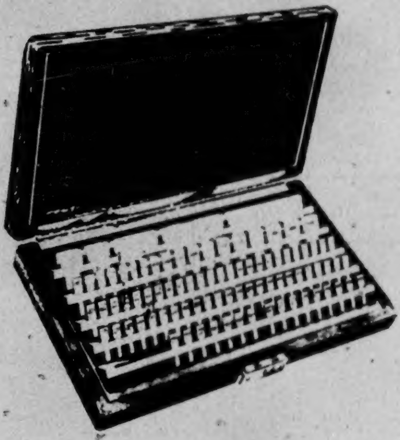
4. Bench or pedestal grinder



5. Layout tool

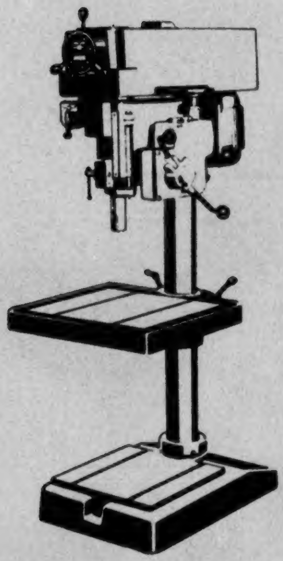


6. Inspection tool

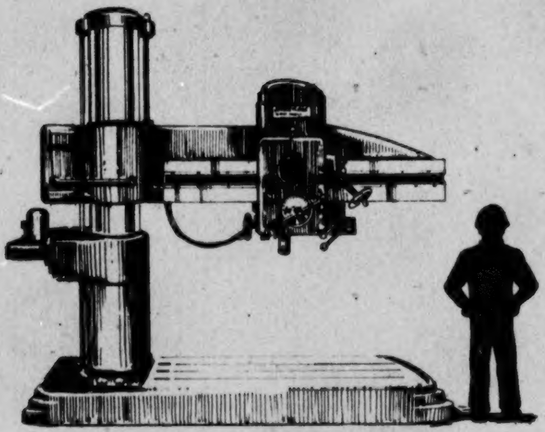


INFORMATION SHEET

B. Drill press

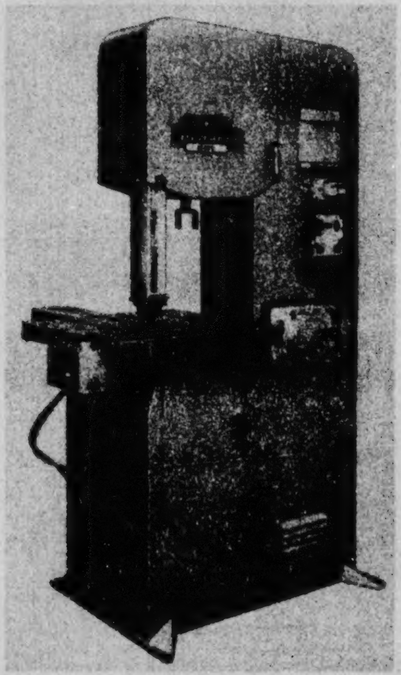


C. Radial drill press



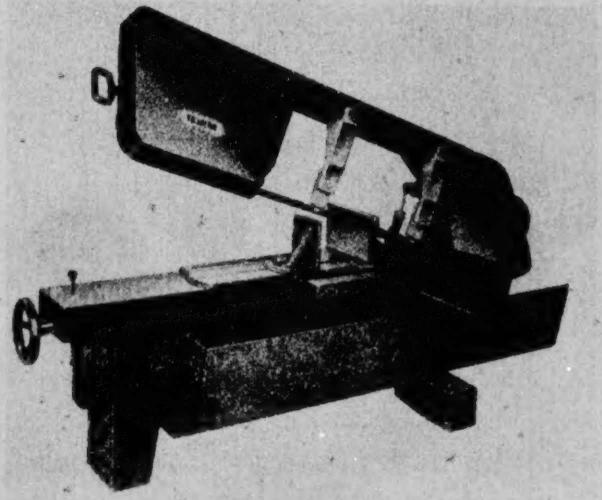
INFORMATION SHEET

D. Vertical band saw



Courtesy of Kalamazoo Saw Division, KTS Industries

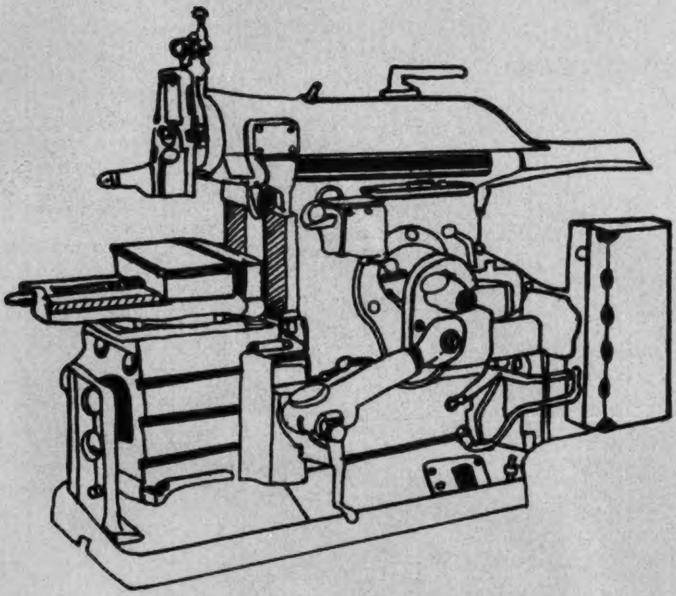
E. Horizontal band saw



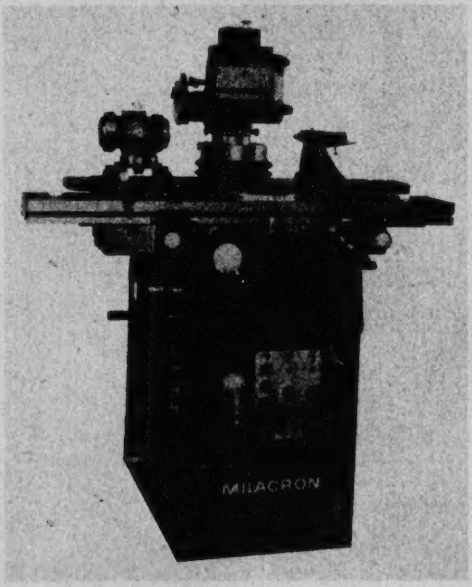
Courtesy of Kalamazoo Saw Division, KTS Industries

INFORMATION SHEET

F. Shaper

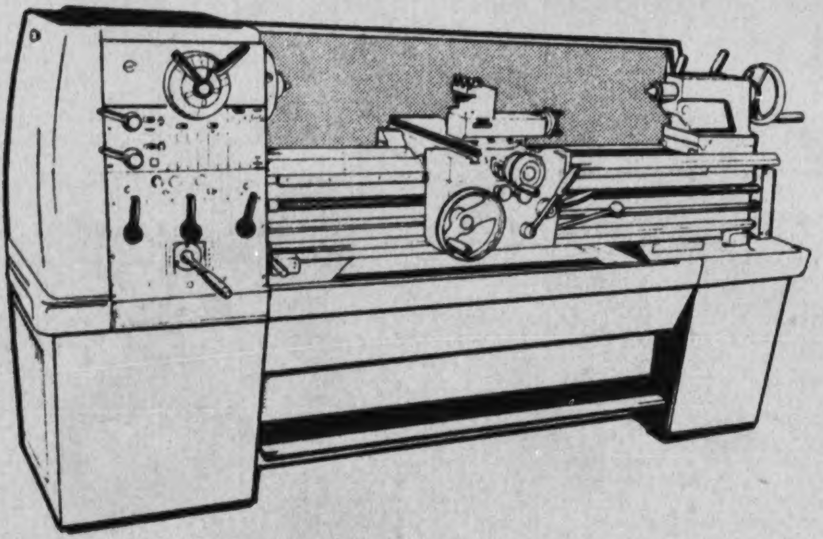


G. Tool and cutter grinder

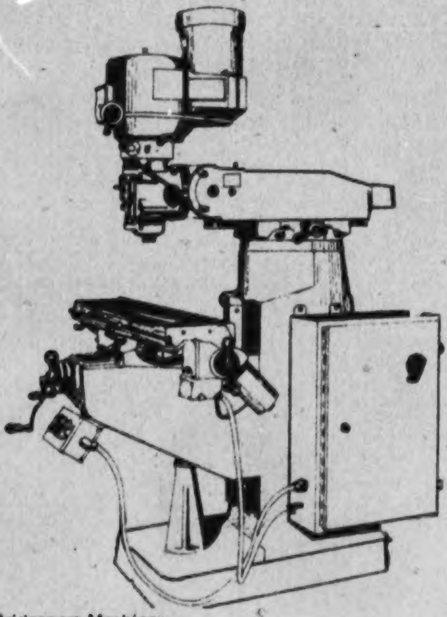


INFORMATION SHEET

H. Engine lathe



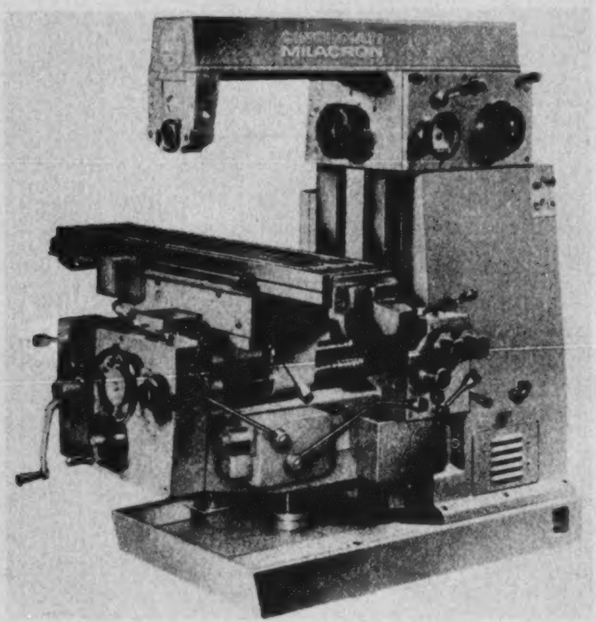
I. Ram and turret mill



Courtesy of Bridgeport Machines

INFORMATION SHEET

J. Horizontal mill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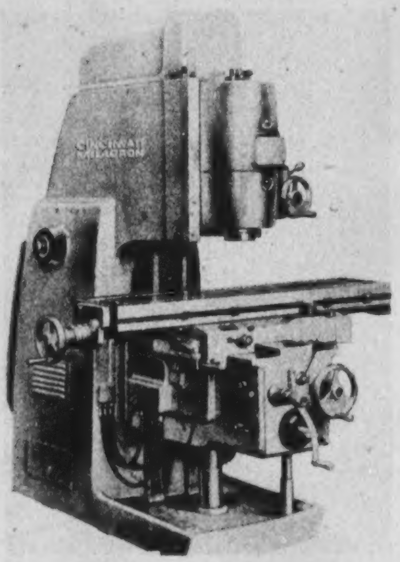
K. Vertical mill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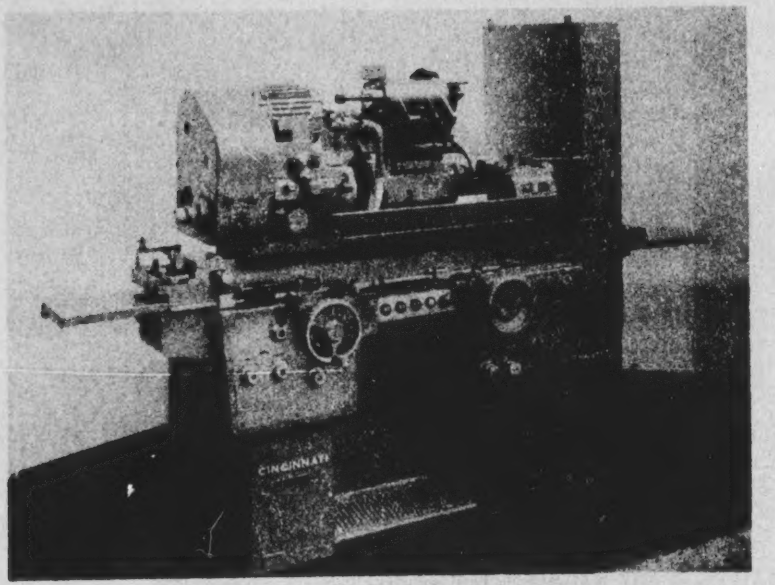
INFORMATION SHEET

L. Cylindrical grinder



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M. Surface grinder

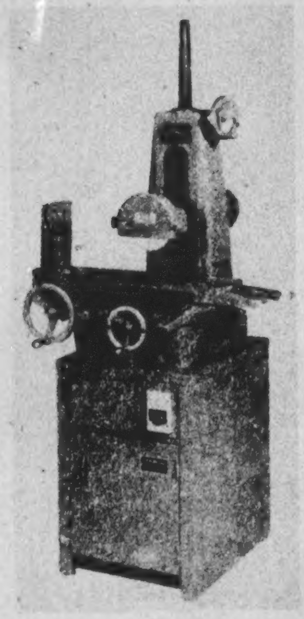
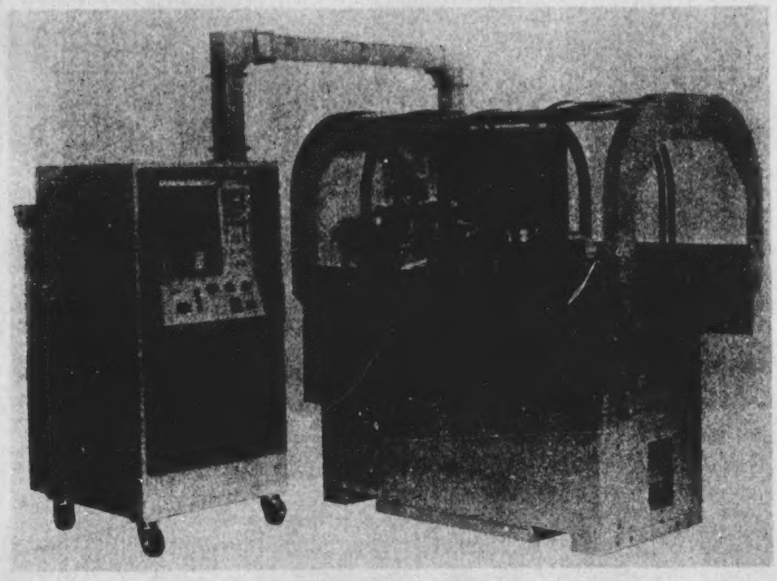


Photo courtesy of MARSUCO

INFORMATION SHEET

N. CNC machine



Courtesy of Hardinge Brothers, Inc.

VI. Guidelines for completing a job application form (Assignment Sheet #3)

A. Print or write clearly

B. Give dates and places of previous employment

C. List three or more references with correct addresses and phone numbers

D. List dates and places where you have attended school

E. Answer all questions, sign and date form

VII. Working conditions and job benefits available to machine trades workers (Assignment Sheet #2)

A. Earnings compare with those of any skilled industrial worker

B. Shops are relatively clean and well-lighted

C. Machining work is generally not strenuous; however, workers usually stand at the job and move about frequently

D. Companies usually pay holidays, vacation, insurance, and other fringe benefits

E. Rapid advancement is possible for the dedicated worker

F. Demand is large for persons to be hired as trainees

MACHINE TRADES ORIENTATION
UNIT I

ASSIGNMENT SHEET #1--SURVEY JOB OPPORTUNITIES FOR MACHINE TRADES WORKERS

NAME ______________________________ SCORE ____________

There are many types of jobs available in the machine trades industry. Also, there are many industries that hire machinists. Using a local or metropolitan Sunday newspaper, clip all the want ads associated with machine shop work.

(NOTE: Use the space below and the back, if necessary, to attach the want ads.)

MACHINE TRADES ORIENTATION
UNIT I

ASSIGNMENT SHEET #2--INTERVIEW A MACHINE TRADES EMPLOYEE

NAME ______________________________ SCORE ______________

Interviewing someone who is working in the trade will help you to determine if this is the kind of work you want to do.

Take this assignment sheet with you during the interview and take notes. Ask the following questions.

1. What made you select this type of job? ______________________________
2. Are you happy with this type of work? ______________________________
3. What do you do on your job? ______________________________
4. What are the strong points of being employed in the machine trades? ______________
5. Would you recommend this type of job for a young person? ______________
6. What type of training is necessary? ______________________________
7. What kind of a future does your job have? ______________________________
8. What tools do I need to start to work? ______________________________
9. What kind of pay could a vo-tech graduate machinist trainee earn? ______________

ASSIGNMENT SHEET #2

10. Other questions you asked and the responses. ____________________

MACHINE TRADES ORIENTATION
UNIT I

ASSIGNMENT SHEET #3--COMPLETE A JOB APPLICATION FORM

NAME ____ SCORE ____________

A big step toward getting a job is filling out a job application form correctly. There are many questions asked on these forms and you should be familiar with them.

Choose from the jobs you found in Assignment Sheet #1 and apply for one of them as a trainee. Fill out the job application form on the next page. Complete all questions on the form. Put *NA* (not applicable) on questions that do not apply to you.

MS I - 23-A

"WE ARE AN EQUAL OPPORTUNITY EMPLOYMENT COMPANY. WE ARE DEDICATED TO A POLICY OF NON-DISCRIMINATION IN EMPLOYMENT ON ANY BASIS INCLUDING RACE, CREED, COLOR, AGE, SEX, RELIGION OR NATIONAL ORIGIN OR PHYSICAL DEFECTS."

APPLICATION FOR EMPLOYMENT

LAST

FIRST

MIDDLE

PERSONAL INFORMATION

DATE

NAME
LAST FIRST MIDDLE

PRESENT ADDRESS
STREET CITY STATE ZIP

PERMANENT ADDRESS
STREET CITY STATE ZIP

PHONE NO. SOCIAL SECURITY NUMBER

REFERRED BY

EMPLOYMENT DESIRED

POSITION DATE YOU CAN START SALARY DESIRED

ARE YOU EMPLOYED NOW? IF SO, MAY WE INQUIRE OF YOUR PRESENT EMPLOYER

EVER APPLIED TO THIS COMPANY BEFORE? WHERE WHEN

EDUCATION	NAME AND LOCATION OF SCHOOL	YEARS ATTENDED	DATE GRADUATED	SUBJECTS STUDIED
GRAMMAR SCHOOL				
HIGH SCHOOL				
COLLEGE				
TRADE, BUSINESS, OR CORRESPONDENCE SCHOOL				

SUBJECTS OF SPECIAL STUDY OR RESEARCH WORK

U.S. MILITARY OR NAVAL SERVICE RANK PRESENT MEMBERSHIP IN NATIONAL GUARD OR RESERVES

ACTIVITIES OTHER THAN RELIGIOUS (CIVIC, ATHLETIC, FRATERNAL, ETC.)

Exclude organizations, the name or character of which indicates the race, creed, color, or national origin of its members.

(CONTINUED ON OTHER SIDE)

24-A

FORMER EMPLOYERS (LIST BELOW LAST FOUR EMPLOYERS, STARTING WITH LAST ONE FIRST.)

DATE MONTH & YEAR	NAME AND ADDRESS OF EMPLOYER	SALARY	POSITION	REASON FOR LEAVING
FROM				
TO				
FROM				
TO				
FROM				
TO				
FROM				
TO				

REFERENCES: Give below the names of two persons not related to you, whom you have known at least one year.

NAME	ADDRESS	BUSINESS	YEARS ACQUAINTED
1			
2			

PHYSICAL RECORD:

List any physical defects

WERE YOU EVER INJURED? GIVE DETAILS

HAVE YOU ANY DEFECTS IN HEARING? IN VISION? IN SPEECH?

IN CASE OF EMERGENCY NOTIFY

NAME ADDRESS PHONE NO.

I AUTHORIZE INVESTIGATION OF ALL STATEMENTS CONTAINED IN THIS APPLICATION. I UNDERSTAND THAT MISREPRESENTATION OR OMISSION OF FACTS CALLED FOR IS CAUSE FOR DISMISSAL. FURTHER, I UNDERSTAND AND AGREE THAT MY EMPLOYMENT IS FOR NO DEFINITE PERIOD AND MAY, REGARDLESS OF THE DATE OF PAYMENT OF MY WAGES AND SALARY, BE TERMINATED AT ANY TIME WITHOUT ANY PREVIOUS NOTICE.

DATE SIGNATURE

DO NOT WRITE BELOW THIS LINE

TO BE COMPLETED DAY EMPLOYMENT BEGINS DATE

HEIGHT WEIGHT AGE DATE OF BIRTH

SINGLE MARRIED WIDOWED CITIZEN U.S.A. SEX

THE ABOVE INFORMATION NEEDED FOR PENSION, HOSPITALIZATION, INSURANCE, ETC., AND NOT FOR HIRING PURPOSES

INTERVIEWED BY DATE REMARKS

NEATNESS		CHARACTER	
PERSONALITY		ABILITY	

HIRED FOR DEPT. POSITION WILL REPORT SALARY WAGES

APPROVED: 1. 2. 3.

EMPLOYMENT MANAGER DEPT. HEAD GENERAL MANAGER

MACHINE TRADES ORIENTATION
UNIT I

TEST

NAME ______________________________ SCORE __________

1. Match job titles associated with machine trades to the correct definitions. Write the correct numbers in the blanks provided. Definitions continue on the next page.

_____ a. Prepares a machine tool for a particular operation or series of operations; work involves mounting and aligning work-holding devices, setting and adjusting cutters, and establishing procedures for operation

_____ b. Checks parts against dimensions specified on blueprint; may also check surface finish and general appearance of part

_____ c. Is considered capable of making all set-ups and operating any machine in the shop; reads blueprints, plans the job procedures from the blueprint, makes math calculations, and then makes the part

_____ d. Operates a specific machine; responsible for checking parts, making minor adjustments, and changing tools

_____ e. Scribes or draws lines showing shape, size, hole locations, and other information necessary to complete a job; uses both precision and other tools

_____ f. Is responsible for making special tools that produce parts; knows materials well and has a high degree of skill

_____ g. Makes all set-ups; works to a high degree of skill on one particular machine

_____ h. Works from prints, sketches, photographs or parts, and must understand machine parts and how they work; has some basic knowledge of welding and electronics

_____ i. Has completed a course at a vocational-technical school or worked in a related job; must have basic knowledge and be willing to undergo additional training to become a machinist

1. Set-up person
2. Machine tool operator
3. Machinist
4. Instrument maker
5. NC and CNC operator
6. Toolroom tender
7. Tool and die maker
8. Machinist trainee
9. Machine specialist
10. NC programmer
11. Layout person
12. Quality control inspector

_____ j. Is responsible for set-up of machine; periodically inspects parts and tooling for tolerance and finish

_____ k. Is responsible for dispensing special tools, keeping tools sharp and in good working condition

_____ l. Works from blueprint to plan sequence of operations and writes the program in the machine language so the part can be made; usually present on initial set-up and run of the part

2. Write four statements concerning occupational outlook for machine trades workers.

   a. ______________________________
   ____

   b. ______________________________
   ____

   c. ______________________________
   ____

   d. ______________________________
   ____

3. Describe personal traits and responsibilities necessary for working in machine trades in the blanks below.

   ____
   ____
   ____
   ____
   ____
   ____

4. Name six types of employers of machine trades workers in the blanks below.

   a. ______________________________
   b. ______________________________
   c. ______________________________

d. ______________________________

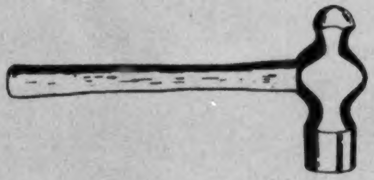
e. ______________________________

f. ______________________________

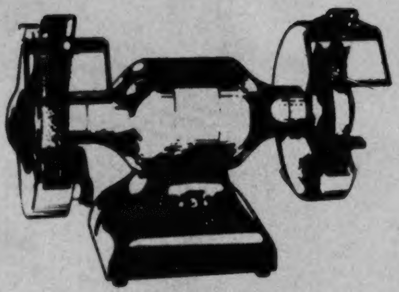
5. Identify common types of equipment used in machine trades shown below and on the next pages. Write the correct names in the blanks provided.

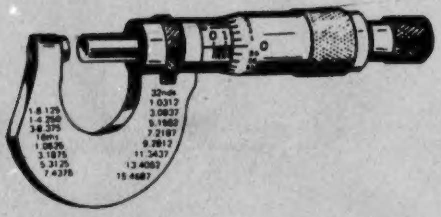
Horizontal band saw
Tool and cutter grinder
Bench or pedestal grinder
Radial drill press
Shaper
Drill press
Hammer
Measuring tool
Punch
CNC machine

Horizontal mill
Vertical band saw
Engine lathe
Cylindrical grinder
Surface grinder
Ram and turret mill
Layout tool
Inspection tool
Vertical mill
Ball peen hammer



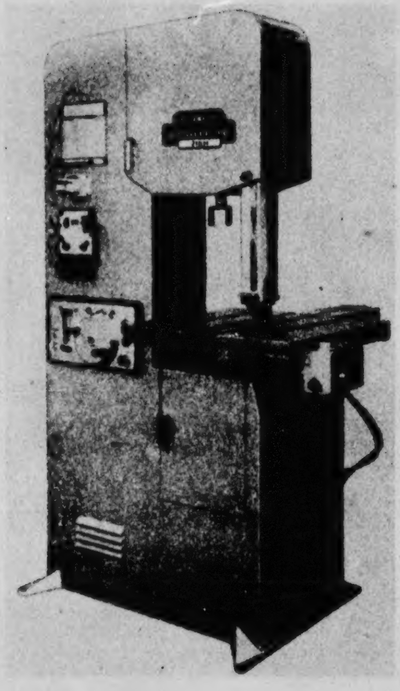
b. ______________________________

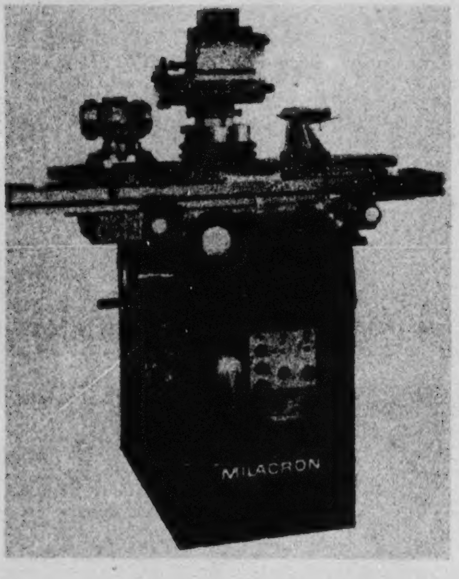




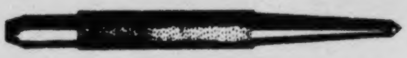
a. ______________________________

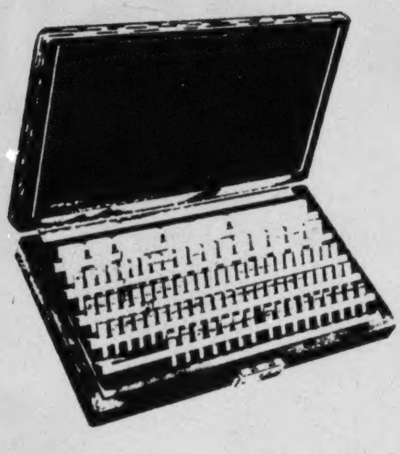
c. ______________________________



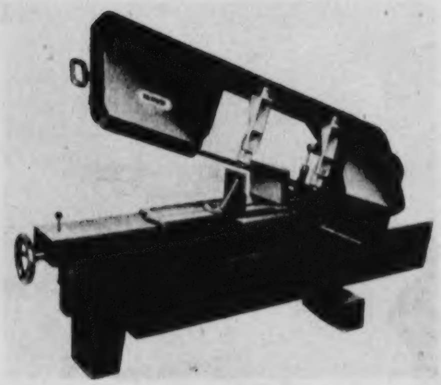


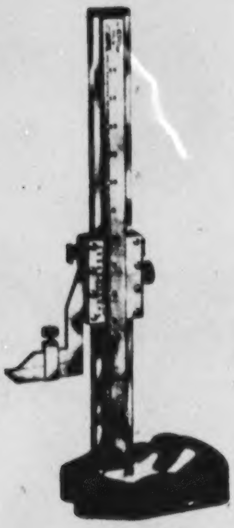
d. ______________________ e. ______________________





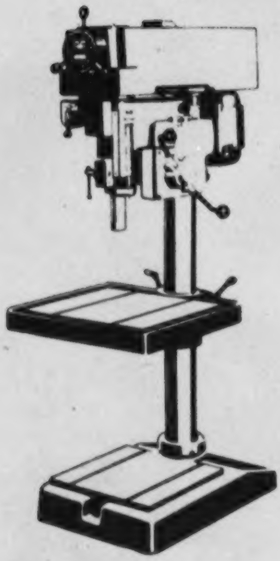
f. ______________________ g. ______________________

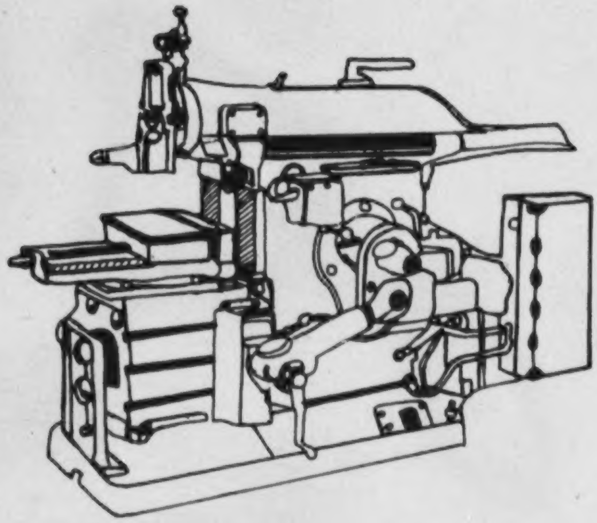




h. ______________________

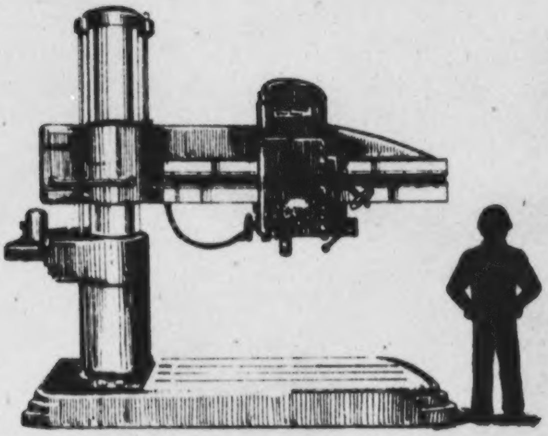
i. ______________________



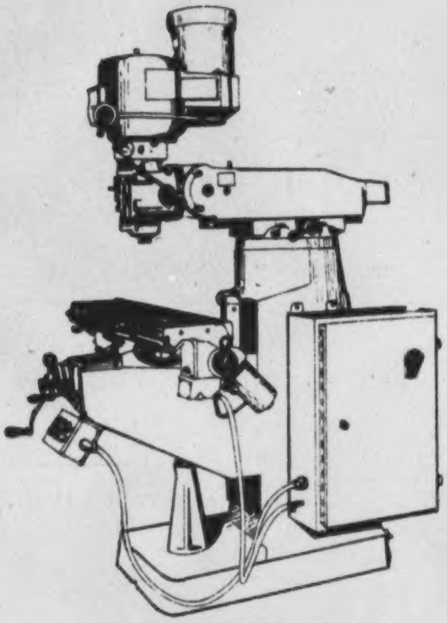


j. ______________________

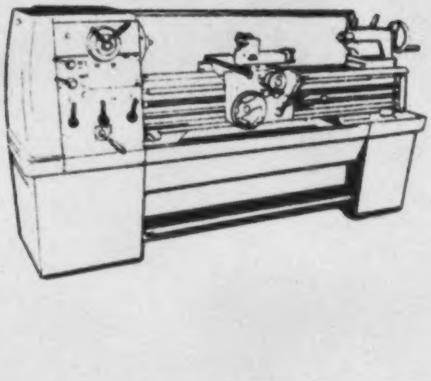
k. ______________________



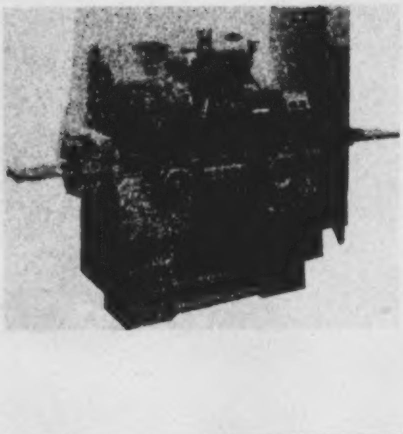
l. ____________________



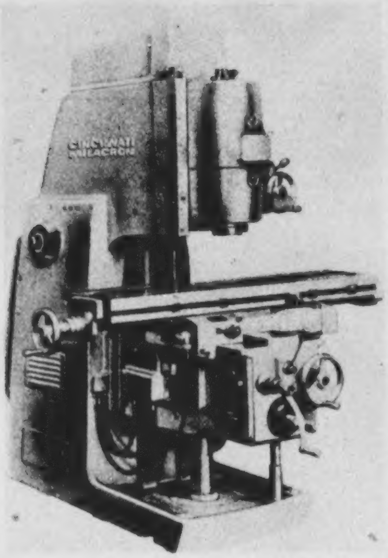
m. ____________________



n. ____________________



o. ____________________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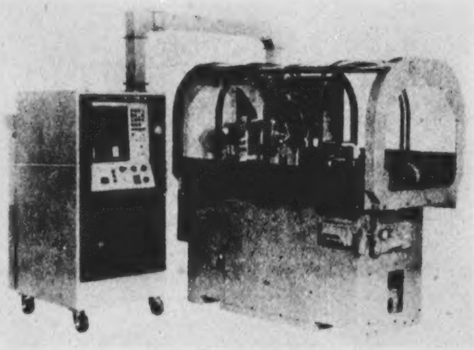
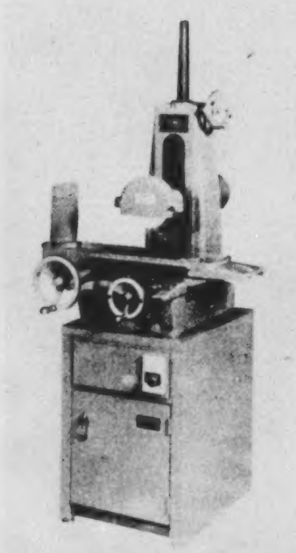
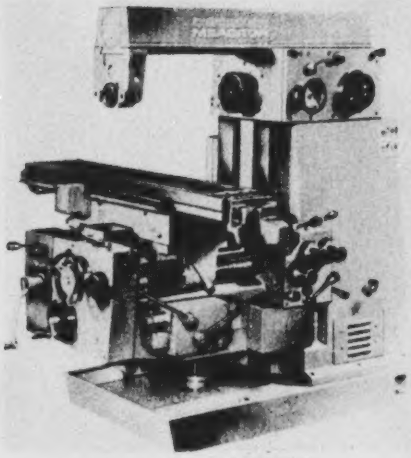


p. ______________________________ q. ______________________________





r. ______________________________ s. ______________________________

6. State five guidelines for completing a job application form.

   a. ______________________________

   b. ______________________________

   c. ______________________________

   d. ______________________________

   e. ______________________________

7. Describe working conditions and job benefits available to machine trades workers.

   a. ______________________________
      ____

   b. ______________________________
      ____

   c. ______________________________
      ____

   d. ______________________________
      ____

   e. ______________________________
      ____

   f. ______________________________
      ____

8. Survey job opportunities for machine trades workers.

9. Interview a machine trades employee.

10. Complete a job application form.

    (NOTE: If activities 8-10 have not been finished before the test, ask your instructor when they should be completed.)

MACHINE TRADES ORIENTATION
UNIT I

ANSWERS TO TEST

(NOTE: The point system designated in parentheses is intended to be a guideline and should be adapted as needed. The point total is 200 including assignment sheets.)

1. (24 points)

   a. 1
   b. 12
   c. 3
   d. 2
   e. 11
   f. 7
   g. 9
   h. 4
   i. 8
   j. 5
   k. 6
   l. 10

2. (8 points)

   Any four of the following:

   a. Machine workers are and will be employed in every state and city in the country
   b. Job openings will result from deaths, retirements, transfers to other fields, and advancing technology
   c. Rapid rise in consumer demand for machined, formed, and molded products will result in higher employment rates
   d. Employment in various machining occupations is expected to increase at different rates
   e. Machine trades workers have excellent opportunities for advancement with experience and special training

3. (7 points)

   Answer should include at least a portion of the following:

   a. Operate shop equipment correctly
   b. Be safety conscious and follow safety regulations
   c. Take instructions readily and follow directions
   d. Show enthusiasm for work
   e. Have pride in the trade
   f. Be conscious of waste in materials and working hours

g. Be neat and orderly
h. Be punctual
i. Control temper
j. Attend work regularly
k. Perform equipment maintenance
l. Follow company regulations

4. (6 points)

Any six of the following:

a. Automotive industry
b. Aerospace industry
c. Aircraft industry
d. Farm machinery industry
e. Private industries
f. Maintenance shops
g. Textile industry
h. Paper industry
i. Oil field industries
j. Gas and chemical industries
k. Marine industry

5. (38 points)

a. Bench or pedestal grinder
b. Ball peen hammer
c. Measuring tool
d. Vertical band saw
e. Tool and cutter grinder
f. Punch
g. Inspection tool
h. Horizontal band saw
i. Layout tool
j. Drill press
k. Shaper
l. Radial drill press
m. Ram and turret mill
n. Engine lathe
o. Cylindrical grinder
p. Vertical mill
q. CNC machine
r. Surface grinder
s. Horizontal mill

6. (10 points)

    a. Print or write clearly

    b. Give dates and places of previous employment

    c. List three or more references with correct addresses and phone numbers

    d. List dates and places where you have attended school

    e. Answer all questions, sign and date form

7. (7 points)

    Answer should include at least a portion of the following:

    a. Earnings compare with those of any skilled industrial worker

    b. Shops are relatively clean and well-lighted

    c. Machining work is generally not strenuous; however, workers usually stand at the job and move about frequently

    d. Companies usually pay holidays, vacation, insurance, and other fringe benefits

    e. Rapid advancement is possible for the dedicated worker

    f. Demand is large for persons to be hired as trainees

8. (33 points) Evaluated to satisfaction of instructor

9. (33 points) Evaluated to satisfaction of instructor

10. (34 points) Evaluated to satisfaction of instructor

GENERAL SHOP SAFETY
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to evaluate unsafe situations and describe rules for shop and personal safety. This knowledge will be evidenced by completion of assignment sheets and unit test with a minimum of 100 percent accuracy.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with shop safety to the correct definitions.
2. Name the components of the fire triangle.
3. Match safety colors to their uses.
4. Describe personal safety.
5. Describe general shop safety.
6. Describe maintenance of clean and orderly shop areas.
7. Match classes of fire to the correct definitions.
8. Select the type of fire extinguisher used for a particular class of fire.
9. Apply rules for fire safety.
10. Interpret the use of safety colors in the shop.
11. Evaluate situations involving hazards.
12. Indicate willingness to work safely by signing safety pledge.
13. Complete general shop safety awareness checklist.

GENERAL SHOP SAFETY
UNIT II

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

   A. Provide students with objective sheet.

   B. Discuss reasons for being safety conscious.

   C. Provide students with information and assignment sheets.

   D. Discuss information sheets.

   E. Discuss assignment sheets.

   F. Tour an industry, and have students watch for safety and fire hazards. Then hold a discussion on their observations.

   G. Invite industry representative to discuss with students the importance of safety on the job.

   H. Go over school shop safety rules with students; give students a copy.

   I. Use Assignment Sheet #5 checklist for discussion on safety awareness.

   J. Point out different types of fire extinguishers, types of fires each is used for, their operation and safe use to students.

      (NOTE: Invite fire department personnel to demonstrate use of fire extinguishers. Make arrangements with fire officials so that each student can learn to operate fire extinguishers.)

   K. Go over school fire and disaster drill plans.

   L. Display safety posters throughout shop and classroom.

      (NOTE: Safety posters can be purchased from *School Shop* magazine, P.O. Box 1072, Skokie, Illinois 60076.)

   M. Contact insurance companies for free safety posters; also invite insurance company representative to give safety lectures.

   N. Invite highway patrol to make presentation on alertness and how it can prevent accidents.

   O. Give test.

   P. Reteach if necessary.

II. Instructional materials:

- A. Objective sheet
- B. Information sheet
- C. Assignment sheets
    1. Assignment Sheet #1--Apply Rules for Fire Safety
    2. Assignment Sheet #2--Interpret the Use of Safety Colors in the Shop
    3. Assignment Sheet #3--Evaluate Situations Involving Hazards
    4. Assignment Sheet #4--Indicate Willingness to Work Safely by Signing Safety Pledge
    5. Assignment Sheet #5--Complete General Shop Safety Awareness Checklist
- D. Answers to assignment sheets
- E. Test (to be filed in student's folder)
- F. Answers to test

III. Unit reference--National Standard School Shop Safety Inspection Checklist. Prepared by the Joint Safety Committee of the American Vocational Association--National Safety Council.

GENERAL SHOP SAFETY
UNIT II

INFORMATION SHEET

I. Terms and definitions

A. Safety--The state or condition of being free from danger, risk, or injury

B. Accident--A suddenly-occurring and unintentional event which causes injury or property damage

C. First aid--The immediate, temporary care given the victim of an accident or sudden illness until the services of a physician can be obtained

D. Hazard--A source of danger; condition that can cause an accident

E. Extinguish--To put out

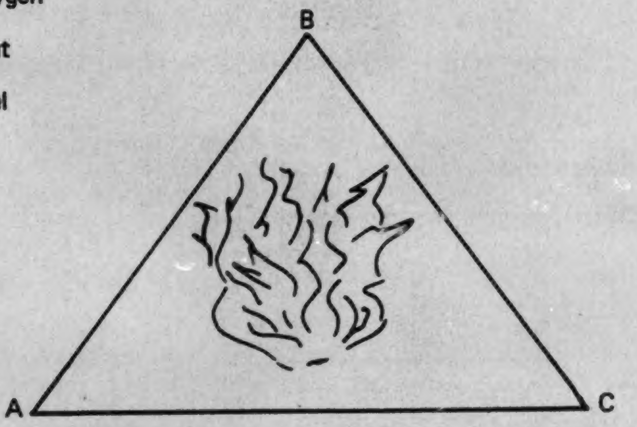
II. Components of the fire triangle (Assignment Sheet #1)

(NOTE: All these conditions must be met to sustain a fire.)

A. Oxygen

B. Heat

C. Fuel



III. Uses of safety colors (Assignment Sheet #2)

A. Green--Shows location of safety and first aid equipment; also shows location of eyewash shower

B. Yellow--Shows hazardous areas where caution or eye protection is needed; points out crushing or shearing hazards on machinery

C. Orange--Shows electrical hazards on machinery

INFORMATION SHEET

D. Red--Shows location of emergency equipment, fire extinguishers, fire exits, stop switches, and flammable storage containers

E. Blue--Designates equipment under repair

F. Ivory--Reflects light and shows the way

IV. Personal safety (Assignment Sheets #3, #4, and #5)

A. Clothing--Wear appropriate shop clothing; do not wear loose clothing that may get caught in machinery

B. Hair--Secure hair to prevent it being caught in revolving equipment

Examples: Roll up into a bun; tucked *completely* under cap; wear with hair net

(NOTE: Short hair is safer.)

C. Eye protection--Wear appropriate eye protection required for the job you are doing

Examples: Wear safety glasses at all times in shop area; wear goggles when using grinders; wear face shield when operating abrasive cut-off machinery to protect face and eyes

D. Headgear--Wear hard hat to prevent head injury where overhead equipment is used

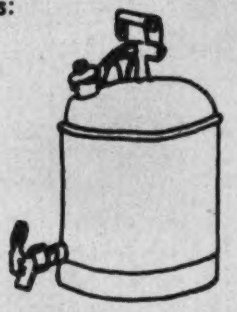
E. Floor area--Keep floor clean and free of obstructions and slippery substances that can cause someone to fall

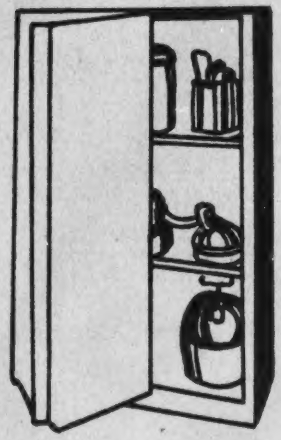
V. General shop safety (Assignment Sheets #3, #4, and #5)

A. Work area--Clutter causes accidents, slows down productivity, and looks bad. Keep your work area clean

B. Combustible materials--Store in can with self-sealing lid; keep all flammable materials in a designated area to help eliminate possibility of fire

Examples:

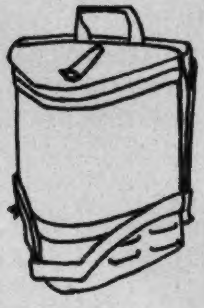




INFORMATION SHEET

C. Oily rags--Store in metal container with self-sealing lid to eliminate fire hazard

Example:



D. Jewelry-Before operating machinery, remove watches, rings, and other jewelry which can get caught in moving parts of the machine and cause injury

E. Safety test--Before operating any machine, you must pass safety test for that machine. This is proof that you understand how to operate it safely

F. Machine in operation--Shut off any machines if instructor leaves the shop area; **NEVER LEAVE AN OPERATING MACHINE UNATTENDED**

G. Leaning on machines--Do not lean against machines as you can slip or fall into machine; also, precision machines must be level

H. Talking to other students while they are operating machinery--This is distracting and can result in injury or damaged equipment

I. Horseplay--Causes accidents and will not be tolerated

J. Injuries--Report all injuries to instructor to determine appropriate first aid action and to complete accident forms

K. Damaged electrical parts--Report them to instructor; **do not try to repair them yourself**

L. Fire--Report all fires to instructor before sounding alarm

M. Lifting--Lift with your legs and keep your back straight, or get help; if you do not know how to lift, ask instructor to demonstrate the correct way

INFORMATION SHEET

N. Moving objects--Do not touch moving parts because you can get cut, caught, or burned

Examples: Chucks, drills, cutters, work that is turning

O. Special safety equipment--Use special safety equipment when required, as it has been designed for your protection

P. Guards--Never operate machines with guards off; these guards are installed for protection from gears, pulleys, belts, etc.

VI. Maintenance of clean and orderly shop areas (Assignment Sheets #3, #4, and #5)

A. Work area--Kept clean to reduce hazards and present a good appearance

B. Trash–Placed in proper containers

C. Aisles and traffic areas--Free of debris to prevent accidents and allow for a fast exit if necessary

D. Tools--Clean and return to proper place when you are through with them so that you and others can find them

E. Cleaning equipment--Kept in central location

VII. Classes of fire (Assignment Sheet #1)

A. Class A--Fires that occur in ordinary combustible materials, such as wood, rags, and rubbish

B. Class B--Fires that occur with flammable liquids, such as gasoline, oil, grease, paints, and thinners

C. Class C--Fires that occur in or near electrical equipment such as motors, switchboards, and electrical wiring

D. Class D--Fires that are caused by burning metal (magnesium)

(CAUTION: GET AWAY FROM MAGNESIUM FIRES IMMEDIATELY.)

VIII. Types of fire extinguishers (Assignment Sheet #1)

(NOTE: Many fire extinguishers can be used on several types of fires. A higher level extinguisher can be used on a lower-level fire, but not the other way around.)

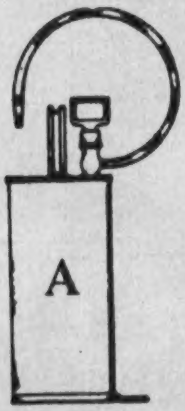
Example: A Class C extinguisher can be used to put out a Class A fire, but a Class A extinguisher will not put out a Class C fire

INFORMATION SHEET

A. Pressurized water--Used on Class A fires

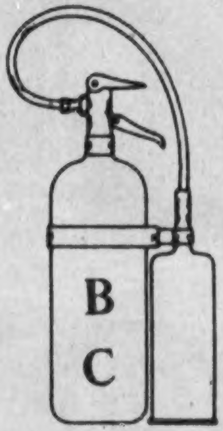
(NOTE: Pressurized water extinguishers are usually operated by squeezing a handle or trigger.)

Example:



B. Carbon dioxide (CO_2)--Used on Class B and C fires

(NOTE: Carbon dioxide extinguishers are usually operated by squeezing a handle or trigger.)

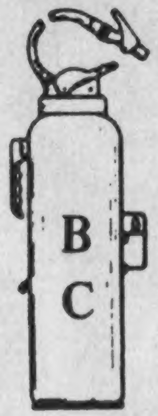


INFORMATION SHEET

C. Dry chemical--Used on Class B and C fires

(NOTE: Dry chemical extinguishers are usually operated by squeezing a handle, trigger, or lever.)

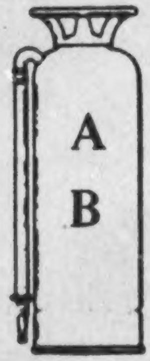
Example:



D. Foam--Used on Class A and B fires

(NOTE: Foam extinguishers are operated by turning the extinguisher upside down.)

Example:

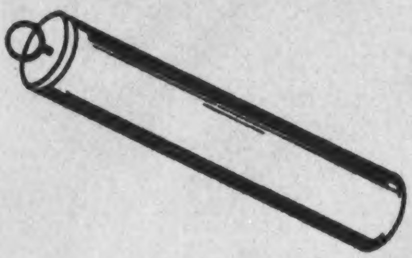


INFORMATION SHEET

E. Special dry chemical--Used on Class D fires

(NOTE: Special dry chemicals are usually in a tube; they are operated by removing the top and shaking the chemical on burning metal. They smother fires by cutting off oxygen.)

Example:



GENERAL SHOP SAFETY
UNIT II

ASSIGNMENT SHEET #1--APPLY RULES FOR FIRE SAFETY

NAME ______________________________ SCORE __________

Fire is always a possibility in a shop. The more you understand about fire and its causes, the better chance you have of eliminating this hazard. Answer the following questions:

1. Name the three components of a fire.

   a. ______________________________

   b. ______________________________

   c. ______________________________

2. Explain what is meant by class of fire.

   ____

   ____

   ____

3. To put out an electrical fire, a Class _____ extinguisher should be used.

4. To put out a paper or waste fire, a Class _____ extinguisher should be used.

5. To put out a gasoline fire, a Class _____ extinguisher should be used.

6. Who is the first person you should notify in the event of a fire?

   ____

GENERAL SHOP SAFETY
UNIT II

ASSIGNMENT SHEET #2--INTERPRET THE USE OF SAFETY COLORS IN THE SHOP

NAME ______________________________ SCORE ____________

Color coding is a visual way of showing safety. Think of the different colors as road signs alerting you to different safety hazards.

Match the safety colors to their uses. Write the correct letters in the blanks provided. Some colors will be used more than once.

a. Red
b. Yellow
c. Orange
d. Green
e. Blue
f. Ivory

1. _____ Shows the location of first aid equipment
2. _____ Shows a hazardous area on equipment, like the inside of an electrical fuse box
3. _____ Shows the location of fire-fighting equipment
4. _____ Shows a caution or hazardous area like a step-off or low-hanging pipe
5. _____ Shows that a machine is out of order or under repair
6. _____ Shows the way out of the building, like a marked aisle
7. _____ Shows the location of the stop switch on a machine
8. _____ Shows that an area is a potential hazard from something like the pressure pads of a hydraulic shear
9. _____ Shows location of an eyewash shower
10. _____ Shows areas where eye protection is needed

GENERAL SHOP SAFETY
UNIT II

ASSIGNMENT SHEET #3--EVALUATE SITUATIONS INVOLVING HAZARDS

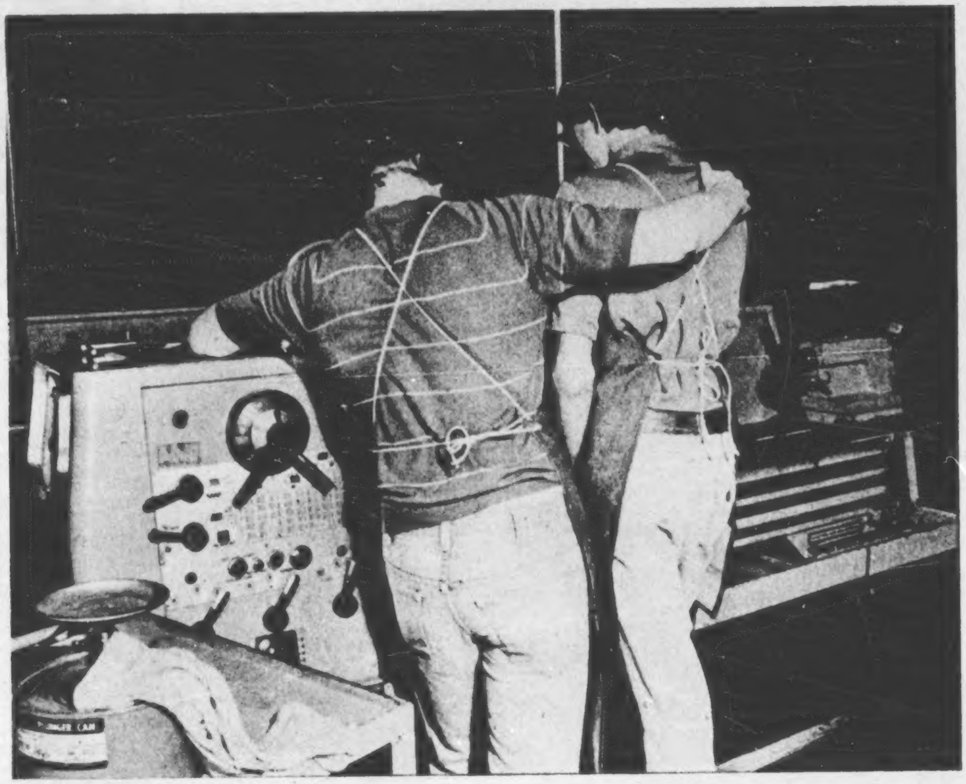
NAME ____________________ SCORE __________

Machines are slaves designed to do your bidding, but they are only as safe as the person using them. Machines don't think, but you must if the job you are performing is to be accident-free.

Study each of the following photographs, and state which safety rules are not being observed.

(NOTE: Photographs will have more than one safety violation.)

1.



a. ____________________

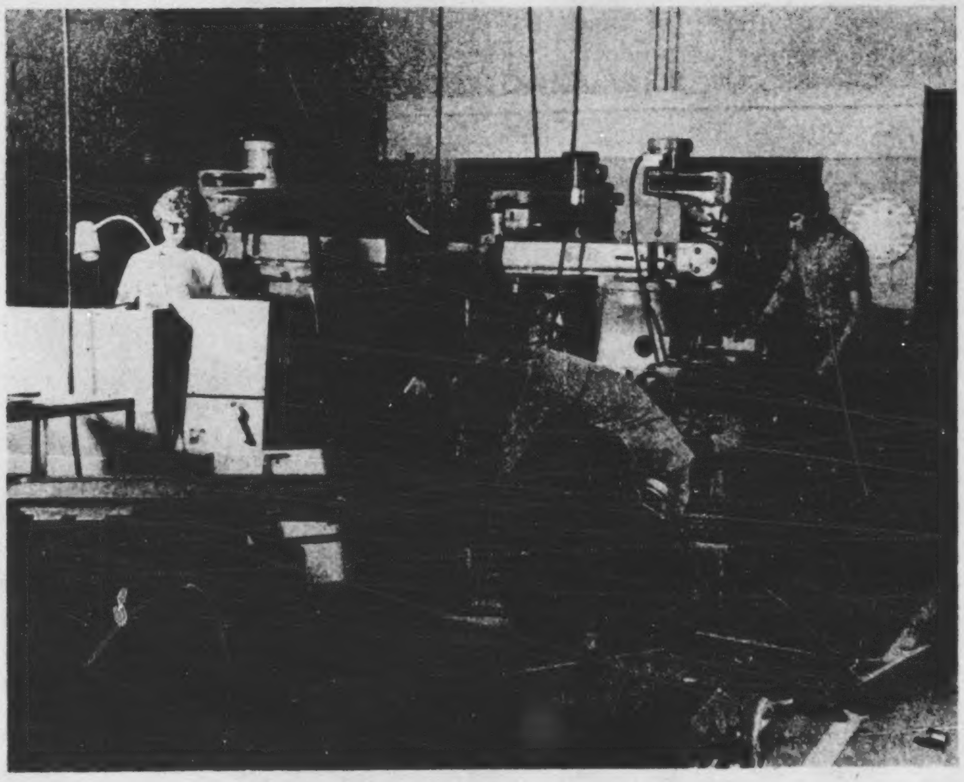
b. ____________________

c. ____________________

d. ____________________

ASSIGNMENT SHEET #3

2.



a. ______________________________

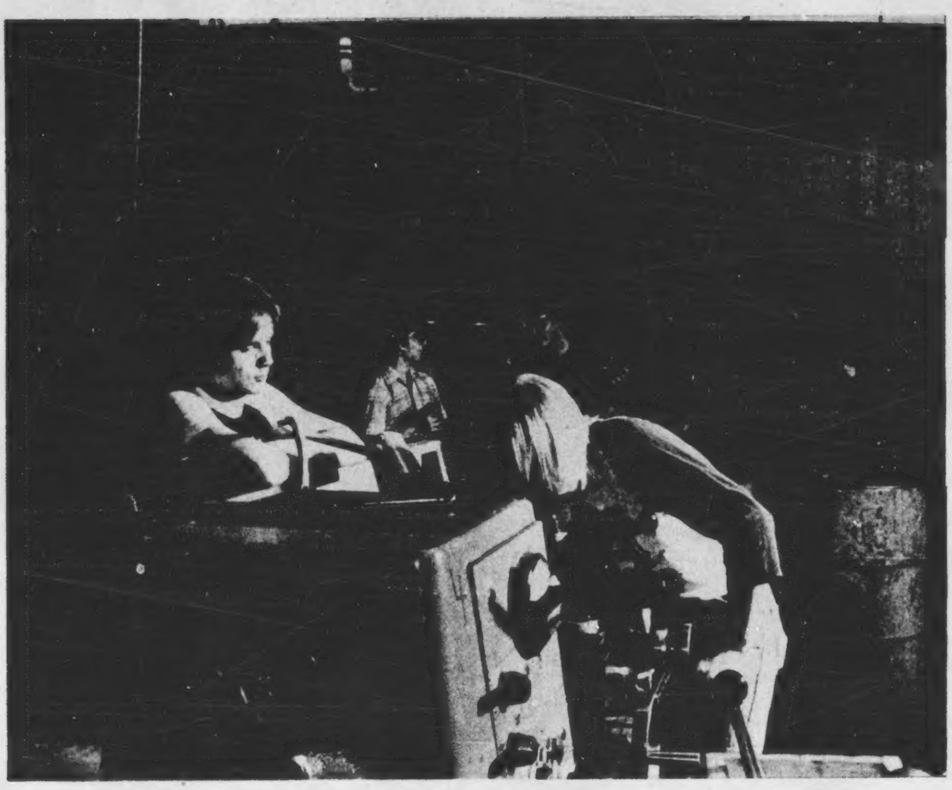
b. ______________________________

c. ______________________________

d. ______________________________

ASSIGNMENT SHEET #3

3.



a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

GENERAL SHOP SAFETY
UNIT II

ASSIGNMENT SHEET #4--INDICATE WILLINGNESS TO WORK SAFELY BY SIGNING SAFETY PLEDGE

NAME ____

STUDENT SAFETY PLEDGE FORM

______________________________, who is enrolled in Vocational Machine Shop, will, as a part of the shop experience, operate machines, providing that parent or guardian gives written permission.

It is understood that each student will be given proper instruction, both in the use of the equipment and in correct safety procedures concerning it, before being allowed to operate it. The student must assume responsibility for following safe practices, and we therefore ask that the following safety pledge be signed.

1. I PROMISE TO ABIDE BY SCHOOL POLICIES AS STATED IN STUDENT HANDBOOK.
2. I PROMISE TO FOLLOW ALL SAFETY RULES FOR THE SHOP.
3. I PROMISE NEVER TO USE A MACHINE WITHOUT FIRST HAVING PERMISSION FROM THE INSTRUCTOR.
4. I WILL NOT ASK PERMISSION TO USE A PARTICULAR MACHINE UNLESS I HAVE BEEN INSTRUCTED IN ITS USE, AND HAVE SCORED 100% ON THE SAFETY TEST FOR THAT MACHINE.
5. I WILL REPORT ANY ACCIDENT OR INJURY TO THE TEACHER IMMEDIATELY.
6. I UNDERSTAND THAT FAILURE TO FOLLOW SAFETY REGULATIONS IS GROUNDS FOR DISMISSAL.

DATE____________ STUDENT'S SIGNATURE ____________________

I hereby give my consent to allow my child to operate all machines and equipment necessary in carrying out the requirements of the course.

DATE____________ SIGNATURE OF PARENT OR GUARDIAN____________________

Parents and/or guardians are cordially invited to visit the shop to inspect the machines and to see them in operation.

GENERAL SHOP SAFETY
UNIT II

ASSIGNMENT SHEET #5--COMPLETE GENERAL SHOP SAFETY AWARENESS CHECKLIST

NAME ______________________________ SCORE ____________

Safety awareness develops good safety practices. Use the school shop area to complete checklist.

Draw a circle around the appropriate letter, using the following letter scheme:

S--Satisfactory (needs no attention)
A--Acceptable (needs some attention)
U--Unsatisfactory (needs immediate attention)

Recommendations should be made in all cases where a "U" is circled. Space is provided at the end of each section for such comments. Designate the items covered by the recommendations by using the letter and number applicable (as B-2).

In most categories, space is provided for listing the standards, requirements or regulations which have local application only.

A. GENERAL PHYSICAL CONDITION

1. Machines, benches, and other equipment are arranged so as to conform to good safety practices S A U
2. Condition of stairways S A U
3. Condition of aisles S A U
4. Condition of floors S A U
5. Condition of walls, windows, and ceiling S A U
6. Lighting is safe, sufficient, and well placed S A U
7. Ventilation is adequate and proper for conditions S A U
8. Fire extinguishers are of proper type, in adequate supply, properly located and maintained S A U
9. Teacher and pupils know location of and how to use proper types of extinguishers for various fires S A U
10. Number and location of exits are adequate and properly identified S A U
11. Proper procedures have been demonstrated and posted for emptying the room of pupils and taking adequate precautions in case of emergencies S A U

ASSIGNMENT SHEET #5

12. Lockers are inspected regularly for cleanliness and fire hazards S A U
13. Locker doors are kept clean S A U
14. Walls are clear of objects that might fall S A U
15. Teachers know the procedure in the event of fire, including notification of the fire department and the evacuation of the building S A U
16. Air in shop is free from excessive dust, smoke, etc. S A U
17. Comments or additional physical conditions evaluated:
18. ______________________________
19. ______________________________
20. ______________________________

Evaluation for the total rating of GENERAL PHYSICAL CONDITION S A U

B. HOUSEKEEPING

1. General appearance as to orderliness S A U
2. Adequate and proper storage space for tools and materials S A U
3. Benches are kept orderly S A U
4. Corners are clean and clear S A U
5. Special tool racks, in orderly condition, are provided at benches and machines S A U
6. Tool, supply, and/or material room is orderly S A U
7. Sufficient scrap boxes are provided S A U
8. Scrap stock is put in scrap boxes promptly S A U
9. Materials are stored in an orderly and safe condition S A U
10. A covered metal container is provided for oily rags S A U
11. Containers for oily rags are frequently and regularly emptied S A U

ASSIGNMENT SHEET #5

12. Dangerous materials are stored in metal cabinets S A U

13. Machines and safety areas have been color coded S A U

14. Safety cans are provided for flammable liquids S A U

15. Bulk storage of dangerous materials is provided outside of the main building S A U

16. Protective railing is provided for overhead storage S A U

17. Flammable liquids are not used for cleaning purposes S A U

18. Floors are free of oil, water, and foreign material S A U

19. Floors, walls, windows, and ceilings are cleaned periodically S A U

20. Comments or additional housekeeping conditions evaluated:

21. ____

22. ____

23. ____

Evaluation for the total rating for HOUSEKEEPING S A U

C. EQUIPMENT

1. Machines are arranged so that workers are protected from hazards of other machines, passing students, etc. S A U

2. Danger zones are properly indicated and guarded S A U

3. All gears, moving belts, etc., are protected by permanent enclosure guards S A U

4. All guards are used as much as possible S A U

5. All equipment control switches are easily available to operator S A U

6. All machines are to be shut down when instructor is out of the room S A U

7. Brushes are used for cleaning equipment S A U

8. Nonskid areas are provided around machines S A U

9. Machines not in safe working condition are properly tagged S A U

ASSIGNMENT SHEET #5

10. Machines are guarded to comply with state safety codes S A U

11. Adequate supervision is maintained when students are using machines and tools S A U

12. Tools are kept sharp, clean, and in safe working order S A U

13. All hoisting devices are in safe operating condition S A U

14. Comments or additional equipment evaluated:

15. ____

16. ____

17. ____

Evaluation for the total rating for EQUIPMENT S A U

D. ELECTRICAL INSTALLATION

1. All switches are enclosed S A U

2. There is a master control switch for all of the electrical installations S A U

3. Electrical outlets and circuits are properly identified S A U

4. All electrical extension cords are in safe condition and are not carrying excessive loads S A U

5. All machine switches are within easy reach of the operators S A U

6. Electrical motors and equipment are wired to comply with the National Electric Code S A U

7. Individual cut-off switches are provided for each machine S A U

8. Machines are provided with overload and underload controls by magnetic pushbutton controls S A U

9. No temporary wiring in evidence S A U

10. Comments or additional electrical equipment evaluated:

11. ____

12. ____

13. ____

Evaluation for the total rating for ELECTRICAL INSTALLATION S A U

ASSIGNMENT SHEET #5

E. PERSONAL PROTECTION

1. Safety glasses, goggles or protective shields are provided and required for all work where eye hazards exist S A U
2. Hoods and goggles are properly disinfected S A U
3. Proper shields and goggles are provided for welding S A U
4. Rings and other jewelry are removed by pupils when working in the shop S A U
5. Proper kind of wearing apparel is worn and worn properly for the job being done S A U
6. Leather shoes are worn in shop area S A U
7. Students are examined for safety knowledge S A U
8. Sleeves are rolled above elbows when operating machines S A U
9. Clothing of students is free from loose sleeves, ties, loose coats, etc. S A U
10. Comments or additional personal protection evaluated:
11. ______________________________
12. ______________________________
13. ______________________________

Evaluation for the total rating for PERSONAL PROTECTION S A U

F. INSTRUCTION

1. Shop safety is taught as an integral part of each teaching unit S A U
2. Safety rules are posted, particularly at each danger station S A U
3. Printed safety rules are given to each student S A U
4. Pupils take a safety pledge S A U
5. Safety inspector is used S A U
6. Student shop safety committee is used S A U
7. Motion and/or slide films on safety are used in the instruction S A U

ASSIGNMENT SHEET #5

8. There is a suggestion box	S A U
9. Safety tests are given	S A U
10. Safety posters are used	S A U
11. Talks on safety are given to the classes by industrial workers	S A U
12. Periodic safety inspections of the shop are made by a student committee	S A U
13. Student shop safety committee investigates all accidents	S A U
14. A proper record is kept of safety instructions which are given, showing the signature of student on tests given in this area	S A U

15. Comments or additional instruction evaluated:

16. ______________________________

17. ______________________________

18. ______________________________

Evaluation for the total rating for INSTRUCTION S A U

G. ACCIDENT RECORDS

1. There is a written statement outlining the proper procedure when and if a student is hurt	S A U
2. Adequate accident statistics are kept	S A U
3. Accidents are reported to the proper administrative authority by the instructor	S A U
4. Accident reports are analyzed for instructional purposes and to furnish the basis for elimination of hazards	S A U

5. Comments or additional accident records evaluated:

6. ______________________________

7. ______________________________

8. ______________________________

Evaluation for the total rating for ACCIDENT RECORDS S A U

ASSIGNMENT SHEET #5

H. FIRST AID

1.	An adequately stocked first aid cabinet is provided	S A U
2.	First aid is administered by a qualified individual	S A U
3.	The school has individuals qualified to administer first aid	S A U
4.	Comments or additional first aid evaluated:	
5.	______________________________	
6.	______________________________	
7.	______________________________	
	Evaluation for the total rating for FIRST AID	S A U

GENERAL SHOP SAFETY
UNIT II

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

1. a. Heat
   b. Fuel
   c. Oxygen
2. Fires are classified by type of material that is burning, so that proper extinguishing materials can be applied
3. Class C
4. Class A
5. Class B
6. Your instructor

Assignment Sheet #2

1. d
2. c
3. a
4. b
5. e
6. f
7. a
8. b
9. d
10. b

Assignment Sheet #3

Answers should include a majority of the following:

1. a. Person is leaning on machine
   b. Rag and flammable liquid left out in open
   c. One student is being distracted from work by another student
   d. Tools and equipment left on machine
2. a. Person is operating lathe without guard
   b. Person is operating milling machine without wearing safety glasses
   c. Trash has been left on the floor

d. Person is operating band saw with band guard removed

    1) Person's sleeves are not buttoned or rolled up

    2) Person's hands are too close to blade

3. a. People are engaging in horseplay

    b. Person is leaning on machine and watching lathe operation without wearing safety glasses

    c. Operator's hair is not secured under hat or tied back

GENERAL SHOP SAFETY
UNIT II

TEST

NAME ______________________________ SCORE __________

1. Match terms associated with shop safety to the correct definitions. Write the correct numbers in the blanks provided.

_____a. The state or condition of being free from danger, risk, or injury

_____b. A suddenly-occurring and unintentional event which causes injury or property damage

_____c. The immediate, temporary care given the victim of an accident or sudden illness until the services of a physician can be obtained

_____d. A source of danger; condition that can cause an accident

_____e. To put out

1. Hazard
2. First aid
3. Safety
4. Accident
5. Extinguish

2. Name the components of the fire triangle.

a. ______________________________

b. ______________________________

c. ______________________________

3. Match safety colors to their uses. Write the correct numbers in the blanks provided.

_____a. Shows electrical hazards on machinery

_____b. Shows hazardous areas where caution is needed; points out crushing or shearing hazards on machinery

_____c. Shows location of emergency equipment, fire extinguishers, fire exits, stop switches, and flammable storage containers

_____d. Shows location of safety and first aid equipment

_____e. Designates equipment under repair

_____f. Reflects light and shows the way

1. Green
2. Blue
3. Ivory
4. Red
5. Yellow
6. Orange

4. Describe personal safety in the spaces below.

   a. Clothing-- ______________________________

   b. Hair-- ______________________________

   c. Eye protection-- ______________________________

   d. Headgear-- ______________________________

   e. Floor area-- ______________________________

5. Describe general shop safety in the spaces below.

   a. Work area-- ______________________________

   b. Combustible materials-- ______________________________

   c. Oily rags-- ______________________________

   d. Jewelry-- ______________________________

   e. Safety test-- ______________________________

   f. Machine in operation-- ______________________________

   g. Leaning on machines-- ______________________________

   h. Talking to other students while they are operating machinery-- ______________________________

i. Horseplay- ______________________________

____

j. Injuries-- ______________________________

____

k. Damaged electrical parts-- ______________________________

____

l. Fire- ______________________________

____

m. Lifting-- ______________________________

____

n. Moving objects-- ______________________________

____

o. Special safety equipment- ______________________________

____

p. Guards-- ______________________________

____

6. Describe maintenance of clean and orderly shop areas in the spaces below.

a. Work area- ______________________________

____

b. Trash- ______________________________

c. Aisles and traffic areas-- ______________________________

____

d. Tools-- ______________________________

____

e. Cleaning equipment-- ______________________________

____

7. Match classes of fire to the correct definitions. Write the correct numbers in the blanks provided.

_____ a. Fires that occur in or near electrical equipment such as motors, switchboards, and electrical wiring

_____ b. Fires that occur with flammable liquids, such as gasoline, oil, grease, paints, and thinners

_____ c. Fires that are caused by burning metal (magnesium)

_____ d. Fires that occur in ordinary combustible materials, such as wood, rags, and rubbish

1. Class A
2. Class B
3. Class C
4. Class D

8. Select the type of fire extinguisher used for a particular class of fire. Write the correct numbers in the blanks provided. More than one type of extinguisher may be used on each type of fire.

_____ a. Class A fires

_____ b. Class B fires

_____ c. Class C fires

_____ d. Class D fires

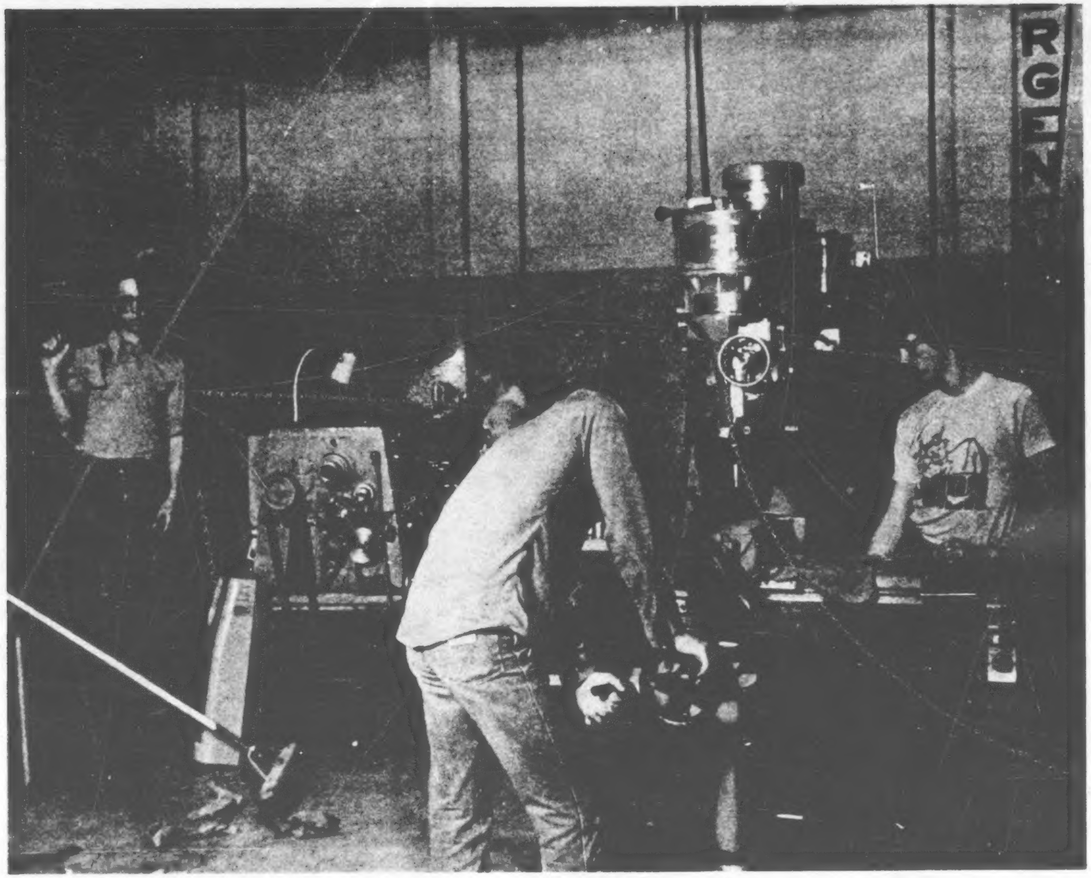
1. Pressurized water
2. Carbon dioxide (CO_2)
3. Dry chemical
4. Foam
5. Special dry chemical

9. Apply rules for fire safety.

10. Interpret the use of safety colors in the shop.

11. Evaluate situations involving hazards using the photographs on the next pages. List each safety violation you see.

PHOTO 1



a. ______________________________

b. ______________________________

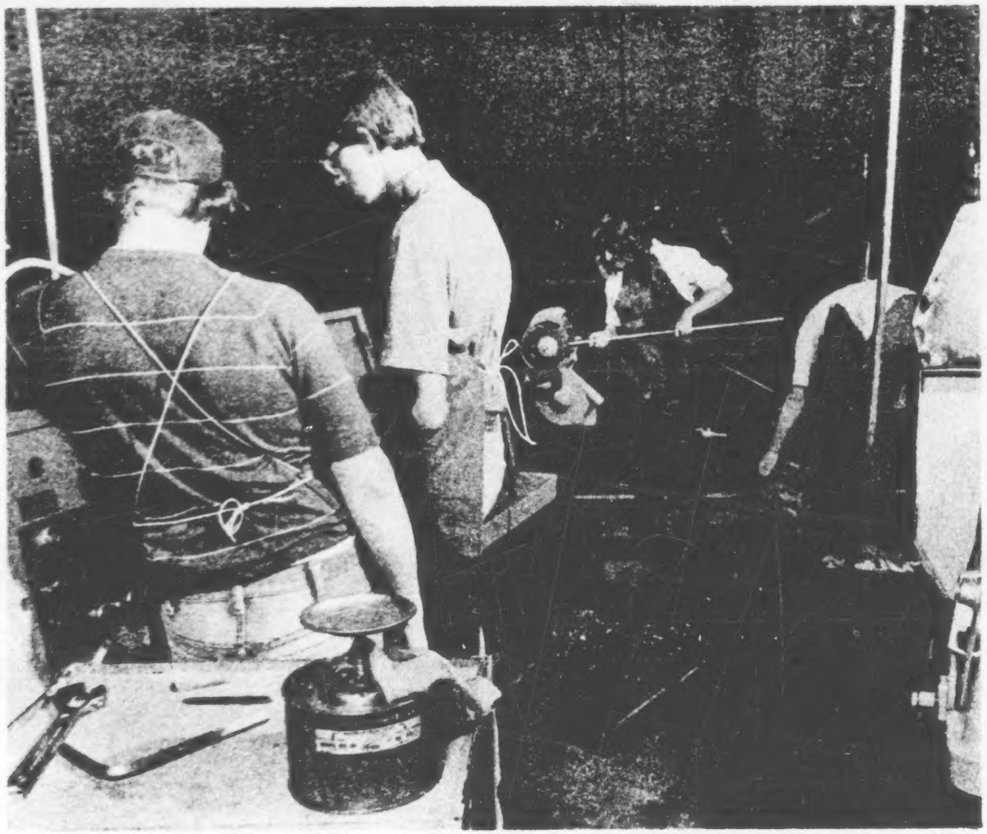
c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

PHOTO 2



g. ____________________

h. ____________________

i. ____________________

j. ____________________

k. ____________________

l. ____________________

m. ____________________

12. Indicate willingness to work safely by signing safety pledge.

13. Complete general shop safety awareness checklist.

(NOTE: If activities 9, 10, 12, and 13 have not been finished before the test, ask your instructor when they should be completed.)

GENERAL SHOP SAFETY
UNIT II

ANSWERS TO TEST

(NOTE: The point system designated in parentheses is intended to be a guideline and should be adapted as needed. The point total is 200, including the assignment sheets.)

1. (10 points)
    a. 3
    b. 4
    c. 2
    d. 1
    e. 5
2. (2 points)
    a. Oxygen
    b. Heat
    c. Fuel
3. (12 points)
    a. 6
    b. 5
    c. 4
    d. 1
    e. 2
    f. 3
4. (10 points)
    a. Clothing--Wear appropriate shop clothing; do not wear loose clothing that may get caught in machinery
    b. Hair--Secure hair to prevent it being caught in revolving equipment
    c. Eye protection--Wear appropriate eye protection required for the job you are doing
    d. Headgear--Wear hard hat to prevent head injury where overhead equipment is used
    e. Floor area--Keep floor clean and free of obstructions and slippery substances that can cause someone to fall

5. (32 points)

Description should include the following points:

a. Work area--Clutter causes accidents, slows down productivity, and looks bad. Keep your work area clean

b. Combustible materials--Store in can with self-sealing lid; keep all flammable materials in a designated area to help eliminate possibility of fire

c. Oily rags--Store in metal container with self-sealing lid to eliminate fire hazard

d. Jewelry--Before operating machinery, remove watches, rings, and other jewelry which can get caught in moving parts of the machine and cause injury

e. Safety test--Before operating any machine, you must pass safety test for that machine. This is proof that you understand how to operate it safely

f. Machine in operation--Shut off any machines if instructor leaves the shop area; **NEVER LEAVE AN OPERATING MACHINE UNATTENDED**

g. Leaning on machines--Do not lean against machines as you can slip or fall into machine; also, precision machines must be level

h. Talking to other students while they are operating machinery--This is distracting and can result in injury or damaged equipment

i. Horseplay--Causes accidents and will not be tolerated

j. Injuries--Report all injuries to instructor to determine appropriate first aid action and to complete accident forms

k. Damaged electrical parts--Report them to instructor; **do not try to repair them yourself**

l. Fire--Report all fires to instructor before sounding alarm

m. Lifting--Lift with your legs and keep your back straight, or get help; if you do not know how to lift, ask instructor to demonstrate the correct way

n. Moving objects--Do not touch moving parts because you can get cut, caught, or burned

o. Special safety equipment--Use special safety equipment when required, as it has been designed for your protection

p. Guards--Never operate machines with guards off; these guards are installed for protection from gears, pulleys, belts, etc.

6. (10 points)

Description should include:

a. Work area--Kept clean to reduce hazards and present a good appearance

b. Trash--Placed in proper containers

c. Aisles and traffic areas--Free of debris to prevent accidents and allow for a fast exit if necessary

d. Tools--Clean and return to proper place when you are through with them so that you and others can find them

e. Cleaning equipment--Kept in central location

7. (8 points)

a. 3

b. 2

c. 4

d. 1

8. (16 points)

a. 1, 4

b. 2, 3, 4

c. 2, 3

d. 5

9. Evaluated to satisfaction of instructor (10 points)

10. Evaluated to satisfaction of instructor (10 points)

11. (50 points)

Answers should include a majority of the following:

PHOTO 1

a. Lathe is being operated with guard removed

b. Person is carrying bar stock improperly

c. Trash is on floor

d. Person is observing milling operation without wearing safety glasses

e. Person operating milling machine has shirttail out, sleeves unbuttoned

f. Rags are left on machine too close to work

PHOTO 2

g. Person is leaning on machine

h. Rag and flammable material have been left out

i. Dustpan and chips are on floor

j. Person is operating grinder without wearing safety glasses and hair is not tied back

k. Person is lifting heavy object improperly

l. Broom is left out, causing a hazard

m. Machine guard on grinder is not in proper place

12. Evaluated to satisfaction of instructor (5 points)

13. Evaluated to satisfaction of instructor (25 points)

BASIC MATH
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to calculate problems using fractions and decimals. This knowledge will be shown by completion of assignment sheets and unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to

1. Match terms associated with fractions and decimal fractions to the correct definitions.
2. Reduce fractions to lowest terms.
3. Convert fractions to equivalent fractions.
4. Change mixed numbers to improper fractions.
5. Change improper fractions to mixed numbers.
6. Determine the lowest common denominator.
7. Add fractions.
8. Subtract fractions.
9. Multiply fractions.
10. Divide fractions.
11. Construct the decimal number system.
12. Write decimal fractions.
13. Convert fractions to equivalent decimal fractions.
14. Write decimal fractions out in words.
15. Add and subtract decimal fractions.
16. Multiply decimal fractions.
17. Divide decimal fractions.

BASIC MATH
UNIT I

SUGGESTED ACTIVITIES

I. Suggested activities for teacher

   A. Provide students with objective sheet and make transparencies.

   B. Provide students with information and assignment sheets.

   C. Discuss unit and specific objectives.

   D. Discuss information and assignment sheets.

   E. Demonstrate the mechanics of solving each type of problem on chalkboard.

   F. Tell students why they need to know how to work these problems.

   G. Show blueprints with calculations that need to be made to reinforce learning (Transparency #2).

   H. Give test.

   I. Reteach if necessary.

II. Instructional materials

   A. Objective sheet

   B. Information sheet

   C. Transparency masters

      1. TM #1--Decimal Equivalents of Common Fractions

      2. TM #2--Applied Math

      3. TM #3--Decimal Numbering System

   D. Assignment sheets

      1. Assignment Sheet #1--Change Fractions

      2. Assignment Sheet #2--Add and Subtract Fractions

      3. Assignment Sheet #3--Multiply and Divide Fractions

      4. Assignment Sheet #4--Convert Fractions and Decimal Fractions

      5. Assignment Sheet #5--Add and Subtract Decimal Fractions

      6. Assignment Sheet #6--Multiply Decimal Fractions

      7. Assignment Sheet #7--Divide Decimal Fractions

SUGGESTED ACTIVITIES

E. Answers to assignment sheets

F. Test

G. Answers to test

III. Unit references

A. Bradley, John G. *Practical Problems in Mathematics for Machinist.* Albany: Delmar Publishers/Division of Litton Educational Publishing, Inc., 1973.

B. Van Leuven, Edwin P. *General Trade Mathematics.* Dallas: Webster Division/McGraw-Hill Book Co., 1952.

BASIC MATH
UNIT I

INFORMATION SHEET

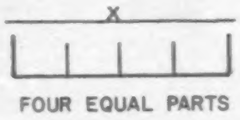
I. Terms and definitions

A. Fraction--A part of a whole; written as two numbers separated by a line

Example: $\frac{1}{4}$

B. Denominator--Tells the number of equal parts something is divided into; written below the line

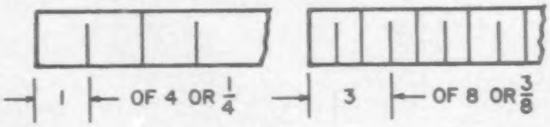
Example: $\frac{x}{\text{Denominator}}$ =



= $\frac{x}{4}$

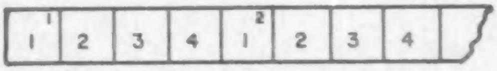
C. Numerator--The portion of the whole that is being considered; written above the line

Example: $\frac{\text{Numerator}}{x}$



D. Improper fraction--The numerator is larger than the denominator, making it larger than a whole unit

Example: $\frac{5}{4}$



The units are divided into
four parts and 5 is one part
larger than the whole unit

E. Mixed number--A whole number and a fraction that have been combined

Examples: $1\frac{1}{4}$, $1\frac{3}{8}$, and $5\frac{3}{16}$

This is a simple way of saying you have 5 units + 3/16 of another unit

INFORMATION SHEET

F. Reducing--Dividing both parts of a fraction by the same number in order to make it easier to read; does not change the value

Example: $\frac{2}{4}$ Each number can be divided by 2, so the fraction can be reduced to $\frac{1}{2}$

G. Decimal fraction--A fraction whose denominator is a power of 10, such as 10, 100, etc. The denominator is omitted and a decimal point is written to the left of the numerator with as many numbers to the right of the decimal point as there were 0's in the denominator

Examples: 1/10 = .1, 1/100 = .01, and 1/1000 = .001

H. Number--One or more whole units

Examples: 1, 7, 15, 187

I. Decimal equivalent--Fraction that has been converted into a decimal

Examples: 1/4 = .250, 1/8 = .125, and 1/2 = .500

J. Lowest common denominator--The smallest number into which two or more denominators can be divided without leaving a remainder

II. Reducing fractions to lowest terms--Dividing both numerator and denominator by the same greatest possible value (Assignment Sheet #1)

(NOTE: A fraction is in its lowest term when both the numerator and denominator cannot be divided by the same number without getting a remainder. Examples of fractions in their lowest terms include 1/2, 3/4, 9/32, and 7/8.)

Examples: 10/16-Both 10 and 16 can be divided by 2 without leaving a remainder

$$\frac{10 \div 2}{16 \div 2} = \frac{5}{8}$$

16/32-Both 16 and 32 can be divided by 2, 4, 8, and 16. Use the largest number

$$\frac{16 \div 16}{32 \div 16} = \frac{1}{2}$$

(NOTE: If you used 2, 4, or 8 the fraction would not be in its lowest term.)

INFORMATION SHEET

III. Converting fractions to equivalent fractions--Multiply both numerator and denominator by the same number (Assignment Sheet #1)

Example: $\frac{3}{8}$ changed to 16ths

$$\frac{3 \times 2}{8 \times 2} = \frac{6}{16}$$

(NOTE: 3/8 = 6/16.)

IV. Changing mixed numbers to improper fractions--Multiply the whole number by the denominator, then add the numerator to the number and place over the original denominator of the fraction (Assignment Sheet #1)

Example: $1\frac{1}{4}$ = 4 times 1 plus 1 = 5, which is the numerator of the improper fraction; $1\frac{1}{4} = \frac{5}{4}$

$2\frac{3}{8}$ = 8 x 2 = 16 + 3 (remainder) = 19 over 8 or $\frac{19}{8}$

V. Changing improper fraction to mixed number--Divide the denominator into the numerator to obtain the whole number, and place the remainder over the original denominator; reduce if necessary (Assignment Sheet #1)

Examples: 13/4

$$\begin{array}{rl} & 3 \leftarrow \text{Whole number} \\ \text{Denominator} \nearrow 4 & \overline{)13} \quad \text{or } 3\ 1/4 \\ & \underline{12} \\ & 1 \leftarrow \text{Remainder} \end{array}$$

14/4 = 3 2/4 Reduce $3\ \frac{2}{4} \div \frac{2}{2} = 3\ 1/2$

VI. Determining the lowest common denominator (LCD)--Determine the smallest number into which all denominators can be divided without leaving a remainder. That number is the lowest common denominator (Assignment Sheet #1)

(NOTE: This operation is usually necessary when adding or subtracting fractions.)

Examples: 1/8, 3/4, 1/2 and 3/16; the smallest number 8, 4, 2, and 16 can be divided into is 16

The lowest common denominator of 1/2, 2/3, and 1/8 is 24. They can all be divided into 48, but 24 is the smallest number into which they can be divided evenly

1/2, 2/3, and 1/8 = 12/24, 16/24, and 3/24

(NOTE: These fractions are equivalent.)

INFORMATION SHEET

VII. Addition of fractions--Change fractions into equivalent fractions having the same LCD; add the numerators together and write that total over the common denominator; reduce or rewrite fraction so it is expressed in its simplest form (Assignment Sheet #2)

Examples: Add 1/2 + 3/4 + 1/16

Determine that 16 is LCD.

$\frac{1 \times 8}{2 \times 8} = \frac{8}{16}$, $\frac{3 \times 4}{4 \times 4} = \frac{12}{16}$, and 1/16 is LCD and no change needed

$\frac{8}{16} + \frac{12}{16} + \frac{1}{16} = \frac{21}{16}$ $\frac{\text{sum of numerator}}{\text{common denominator}}$

(NOTE: Express as 1 5/16 because fractions should always be expressed in their simplest form.)

$$\frac{1}{3} + \frac{1}{2} + \frac{3}{4} = \frac{4}{12} + \frac{6}{12} + \frac{9}{12} = \frac{19}{12} \text{ or } 1\frac{7}{12}$$

$$1\frac{1}{2} + 2\frac{2}{8} + \frac{13}{16} = 1\frac{8}{16} + 2\frac{4}{16} + \frac{13}{16} = 3\frac{25}{16}$$

$$3 + 1\frac{9}{16} = 4\frac{9}{16}$$

(NOTE: The whole numbers were added and there are that many units more than the sum of the fractions.)

VIII. Subtraction of fractions--Change fractions into equivalent fractions having the same LCD, subtract numerators and write difference over the LCD and reduce to lowest terms (Assignment Sheet #2)

Examples: $\frac{3}{4} - \frac{3}{32} = \frac{3 \times 8}{4 \times 8}$ or $\frac{24}{32} - \frac{3}{32} = \frac{21}{32}$

$\frac{15}{16} - \frac{5}{8} = \frac{15}{16} - \frac{5 \times 2}{8 \times 2}$ or $\frac{15}{16} - \frac{10}{16} = \frac{5}{16}$

2 1/4 - 7/8; 2 1/4 = 2 2/8; however, 2/8 is smaller than 7/8 so you must borrow 8/8 or 1 from the 2 and add it to the 2/8 = 1 10/8

$$1\frac{10}{8} - \frac{7}{8} = 1\frac{3}{8}$$

(NOTE: You could have changed 2 1/4 to an improper fraction; then found LCD, subtracted, and changed the improper fraction back to a mixed number.)

9/4 - 7/8 = 18/8 - 7/8 = 11/8 or 1 3/8

INFORMATION SHEET

IX. Multiplication of fractions--Multiply the numerators and denominators separately; write product of the numerator over the product of the denominator and reduce to lowest terms (Assignment Sheet #3)

Examples:

$$\frac{2}{3} \times \frac{1}{2} = \frac{2 \times 1}{3 \times 2} = \frac{2}{6} = \frac{2}{6} \div \frac{2}{2} = \frac{1}{3}$$

$$\frac{1}{4} \times \frac{1}{2} \times \frac{3}{8} = \frac{1 \times 1 \times 3}{4 \times 2 \times 8} = \frac{3}{64}$$

$$1\frac{1}{4} \times \frac{1}{2} = \frac{5}{4} \times \frac{1}{2} = \frac{5}{8}$$

(NOTE: The mixed number was changed to an improper fraction before multiplying.)

X. Division of fractions--Invert the divisor and follow the same procedure as for multiplying (Assignment Sheet #3)

Examples: $\frac{7/8}{1/4}$ or $\frac{7}{8} \div \frac{1}{4}$; $\frac{1}{4}$ is the divisor

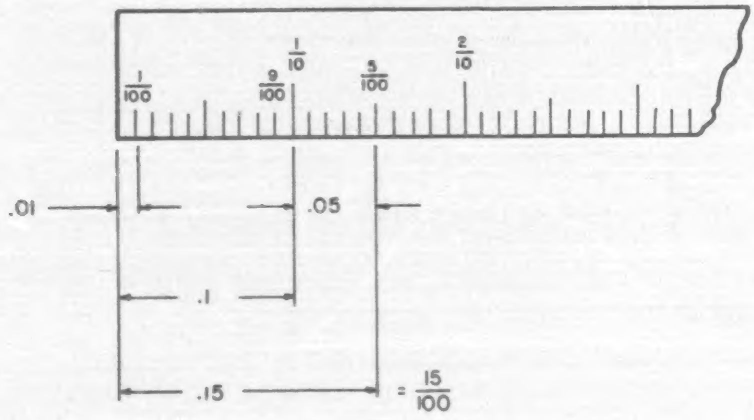
$$\frac{7}{8} \div \frac{1}{4} = \frac{7}{8} \times \frac{4}{1} = \frac{28}{8} = 3\frac{4}{8} = 3\frac{1}{2}$$

$$1\frac{1}{4} \div \frac{1}{2} = \frac{5}{4} \div \frac{1}{2} = \frac{5}{4} \times \frac{2}{1} = \frac{10}{4} \text{ or } 2\frac{2}{4} = 2\frac{1}{2}$$

XI. Constructing the decimal number system--A decimal fraction is not written as a common fraction. The denominator is omitted and replaced with a decimal point placed to the left of the numerator (Transparency #3)

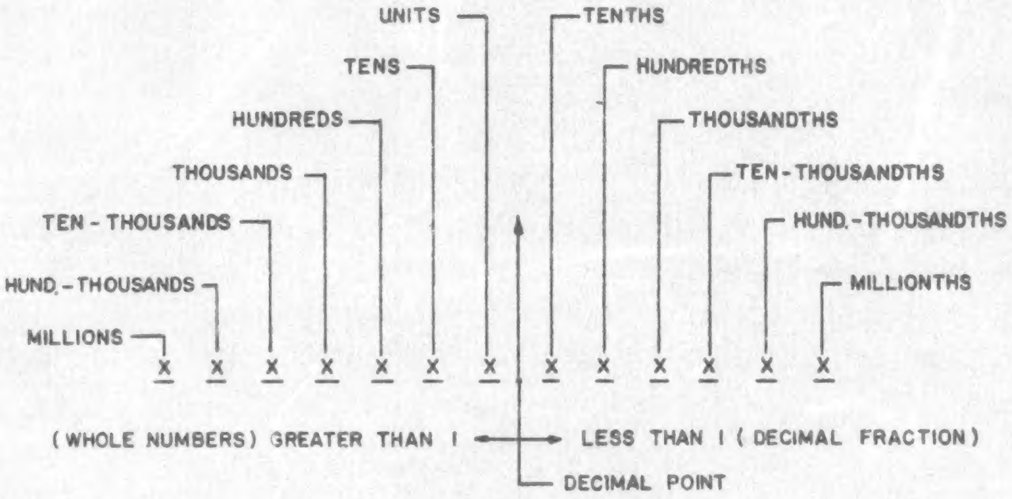
(NOTE: Decimal fractions are fractions whose denominators are powers of 10, such as 10, 100, and 1,000; your answer will have as many numbers to the right of the decimal as there were 0's in the denominator.)

Examples: $2/1\underline{0} = .\underline{2}$ $5/1\underline{00} = .\underline{05}$ $25/1\underline{000} = .\underline{025}$



INFORMATION SHEET

(NOTE: To express these decimal fractions, numbers are written to the right and left of the decimal point. This system is helpful in writing and reading decimals.)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HUND. - THOUSANDTHS
MILLIONTHS
X X X X X X X X X X X X X
(WHOLE NUMBERS) GREATER THAN I
LESS THAN I (DECIMAL FRACTION)
DECIMAL POINT

Examples:

$\frac{1}{10}$ = .1 = one tenth

$\frac{15}{100}$ = .15 = fifteen hundredths

$\frac{5}{1000}$ = .005 = five thousandths

$\frac{210}{10,000}$ = .0210 = Two hundred ten ten-thousandths

$1\frac{5}{1000}$ = 1.005 = One and five thousandths

$4\frac{755}{10,000}$ = 4.0755 = Four and seven hundred fifty-five ten-thousandths

INFORMATION SHEET

XII. Writing the decimal fraction--Omit the denominator and replace it with a decimal point to the left of the numerator. You will have as many places to the right of the decimalpoint as there would be 0's in the denominator (Assignment Sheet #4)

Examples: 2/10 = .2 two tenths; 5/100 = .05 five hundredths; 25/10,000 = .0025 twenty five ten-thousandths

XIII. Converting fractions to equivalent decimal fractions--To convert a fraction to a decimal, divide the denominator into the numerator (Transparency #1, Assignment Sheet #4)

Examples:

$$\frac{1}{2} = \begin{array}{r} .500 \\ 2\overline{)1.000} \\ \underline{1\,0} \\ 0 \end{array} \qquad \frac{3}{4} = \begin{array}{r} .750 \\ 4\overline{)3.000} \\ \underline{2\,8} \\ 20 \\ \underline{20} \\ 0 \end{array}$$

XIV. Writing decimal fractions out in words--To write out a decimal you first look where the decimal point is, then using the number scale (See XI above) read the decimal (Assignment Sheet #4)

Examples: .3 = three tenths; .0025 = twenty-five ten-thousandths; 1.10 = one and ten hundredths; 3.062 = three and sixty-two thousandths

(NOTE: With mixed number decimals such as 3.062, the decimal point was replaced with the word *and.*)

XV. Adding and subtracting decimal fractions--Arrange the numbers so the decimal points are directly under each other and proceed with addition or subtraction of whole numbers from right to left (Transparency #2, Assignment Sheet #5)

Examples:

$$\begin{array}{r} 1.625 \\ \underline{-\ .500} \\ 1.125 \end{array} \qquad \begin{array}{r} 2.562 \\ \underline{-1.875} \\ 0.687 \end{array}$$

(NOTE: When adding or subtracting it helps to fill the problem out by adding zeros [0] to the right of the decimal point to keep your columns straight. They will not change the value of the answer.)

Example:

$$\begin{array}{r} 2.25 \\ .5 \\ 1. \\ \underline{+\ \ .625} \\ 4.375 \end{array} \qquad \begin{array}{r} 2.250 \\ .500 \\ 1.000 \\ \underline{+\ \ .625} \\ 4.375 \end{array}$$

INFORMATION SHEET

XVI. Multiplication of decimal fractions--Multiply by using the same procedure as with whole numbers; the answer will have the same number of decimal places to the right of the decimal point as there are in the sum of the multiplicand and multiplier (Assignment Sheet #6)

(NOTE: The decimal points do not need to be in line in order to multiply.)

Examples:

Multiplicand 25.125 3 places to the right of decimal point
Multiplier .25 + 2 places to the right of decimal point
125625
50250
6.28125 5 places required in answer

.0250 (4 places)
.75 (2 places)
.018750 (6 places)

(NOTE: Add the zeros to the left of the answer until there are enough for the number of places needed.)

XVII. Division of decimal fractions--The divisor must be a whole number, so move the decimal point as many places as necessary. Move the decimal point in the dividend the same number of places, and place the decimal point in the quotient directly above the decimal point in the dividend; then divide (Assignment Sheet #7)

Examples:

Divisor .20⟌.625 Dividend

. Quotient or answer
20⟌62.500 (NOTE: Add zeros to dividend if necessary.)

3.125
20⟌62.500 This problem has been carried out to 3 decimal points, or 3 numbers to the right of the decimal point
60
25
20
50
40
100
100

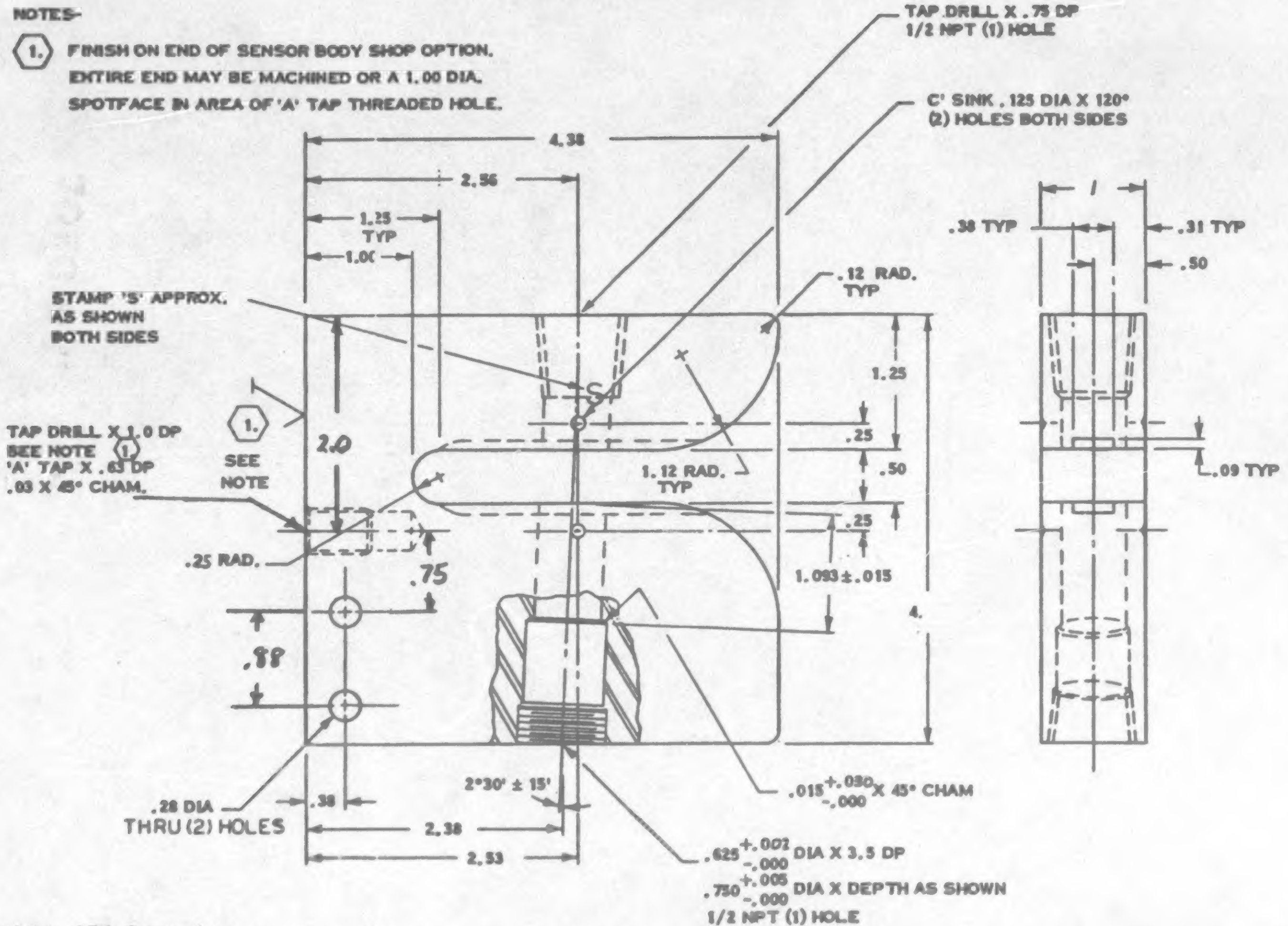
.0625 ÷ 1.5 to (4) decimal places

.0416 10/15 remainder
1.5⟌.06250 After the answer has been carried out to the number of places required, examine the remainder. If it is larger than 1/2 you will round off the last number = .0417
60
25
15
100
90
10

Decimal Equivalents of Common Fractions

Inch Fraction	Inch Decimal	Millimeter	Inch Fraction	Inch Decimal	Millimeter	Inch Fraction	Inch Decimal	Millimeter
.....	.003937	.1	9/32	.28125	7.1438	21/32	.65625	16.6688
.....	.007874	.2	19/64	.296875	7.5406	.....	.669291	17.
.....	.011811	.3	5/16	.3125	7.9375	43/64	.671875	17.0656
1/64	.015625	.3969	.....	.314961	8.	11/16	.6875	17.4625
.....	.015748	.4	21/64	.328125	8.3344	45/64	.703125	17.8594
.....	.019685	.5	11/32	.34375	8.7313	.....	.708661	18.
.....	.023622	.6	.....	.354331	9.	23/32	.718750	18.2563
.....	.027559	.7	23/64	.359375	9.1281	47/64	.734375	18.6531
1/32	.03125	.7938	3/8	.375	9.525	.....	.748031	19.
.....	.031496	.8	25/64	.390625	9.9219	3/4	.750	19.050
.....	.035433	.9	.....	.393701	10.	49/64	.765625	19.4469
.....	.039370	1.	13/32	.40625	10.3188	25/32	.78125	19.8438
3/64	.046875	1.1906	27/64	.421875	10.7156	.....	.787402	20.
1/16	.0625	1.5875	.....	.433071	11.	51/64	.796875	20.2406
5/64	.078125	1.9844	7/16	.4375	11.1125	13/16	.8125	20.6375
.....	.078740	2.	29/64	.453125	11.5094	.....	.826772	21.
3/32	.09375	2.3813	15/32	.46875	11.9063	53/64	.828125	21.0344
7/64	.109375	2.7781	.....	.472441	12.	27/32	.84375	21.4313
.....	.118110	3.	31/64	.484375	12.3031	55/64	.859375	21.8281
1/8	.125	3.175	1/2	.500	12.700	.....	.866142	22.
9/64	.140625	3.5719	.....	.511811	13.	7/8	.875	22.225
5/32	.15625	3.9688	33/64	.515625	13.0969	57/64	.890625	22.6219
.....	.157480	4.	17/32	.53125	13.4938	.....	.905512	23.
11/64	.171875	4.3656	35/64	.546875	13.8906	29/32	.90625	23.0188
3/16	.1875	4.7625	.....	.551181	14.	59/64	.921875	23.4156
.....	.196850	5.	9/16	.5625	14.2875	15/16	.9375	23.8125
13/64	.203125	5.1594	37/64	.578125	14.6844	.....	.944882	24.
7/32	.21875	5.5563	.....	.590551	15.	61/64	.953125	24.2094
15/64	.234375	5.9531	19/32	.59375	15.0813	31/32	.96875	24.6063
.....	.236220	6.	39/64	.609375	15.4781	.....	.984252	25.
1/4	.250	6.350	5/8	.625	15.875	63/64	.984375	25.0031
17/64	.265625	6.7469	.....	.629921	16.	1	1.000	25.400
.....	.275591	7.	41/64	.640625	16.2719	1-1/16	1.0625	26.988

Applied Math



NOTES-

(1.) FINISH ON END OF SENSOR BODY SHOP OPTION. ENTIRE END MAY BE MACHINED OR A 1.00 DIA. SPOTFACE IN AREA OF 'A' TAP THREADED HOLE.

TAP DRILL X .75 DP
1/2 NPT (1) HOLE
C' SINK .125 DIA X 120°
(2) HOLES BOTH SIDES
4.38
2.56
1.25
TYP
1.00
STAMP 'S' APPROX.
AS SHOWN
BOTH SIDES
.12 RAD.
TYP
S
1.25
.25
.50
.25
1.12 RAD.
TYP
1.093±.015
4.
2.0
1.
SEE
NOTE
TAP DRILL X 1.0 DP
SEE NOTE 1
'A' TAP X .63 DP
.03 X 45° CHAM.
.25 RAD.
.75
.88
.28 DIA
THRU (2) HOLES
.38
2°30' ± 15'
2.38
2.53
.015 +.030 -.000 X 45° CHAM
.625 +.002 -.000 DIA X 3.5 DP
.750 +.005 -.000 DIA X DEPTH AS SHOWN
1/2 NPT (1) HOLE
1
.38 TYP
.31 TYP
.50
.09 TYP

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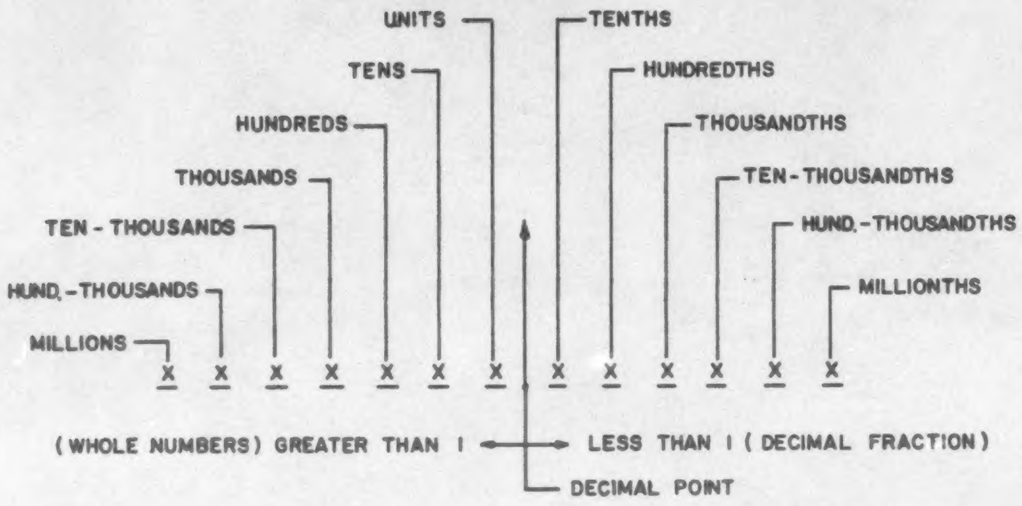
Decimal Numbering System


UNITS
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MILLIONTHS
X X X X X X X . X X X X X X
(WHOLE NUMBERS) GREATER THAN 1
LESS THAN 1 (DECIMAL FRACTION)
DECIMAL POINT

$\frac{1}{10}$ = .1 = one tenth

$\frac{15}{100}$ = .15 = fifteen hundredths

$\frac{5}{1000}$ = .005 = five thousandths

$\frac{210}{10,000}$ = .0210 = Two hundred ten ten-thousandths

$1\frac{5}{1000}$ = 1.005 = One and five thousandths

$4\frac{755}{10,000}$ = 4.0755 = Four and seven hundred fifty-five ten-thousandths

BASIC MATH
UNIT I

ASSIGNMENT SHEET #1--CHANGE FRACTIONS

NAME ______________________________ SCORE ____________________

Developing a good skill with fractions makes you more productive.

1. Reduce each of the fractions to lowest terms. Show your work on all problems.

   a. $\frac{6}{8} =$ _____

   b. $\frac{4}{16} =$ _____

   c. $\frac{14}{16} =$ _____

   d. $\frac{16}{64} =$ _____

ASSIGNMENT SHEET #1

2. Convert fractions to equivalent fractions having the denominators shown.

a. $\frac{1}{4} = \frac{\quad}{16}$

b. $\frac{5}{8} = \frac{\quad}{32}$

c. $\frac{3}{4} = \frac{\quad}{8}$

d. $\frac{7}{8} = \frac{\quad}{64}$

ASSIGNMENT SHEET #1

3. Change mixed numbers to improper fractions.

a. $1\frac{7}{8} =$

b. $5\frac{7}{32} =$

c. $2\frac{1}{2} =$

d. $4\frac{3}{16} =$

ASSIGNMENT SHEET #1

4. Change improper fractions to mixed numbers and reduce if necessary.

a. $\frac{23}{8} =$

b. $\frac{18}{4} =$

c. $\frac{125}{16} =$

d. $\frac{84}{32} =$

ASSIGNMENT SHEET #1

5. Determine the lowest common denominator.

a. $\frac{3}{4}$, $\frac{7}{8}$, $\frac{1}{2}$, and $\frac{3}{32}$ = ______

b. $\frac{1}{2}$, $\frac{3}{5}$, and $\frac{5}{6}$ = ______

ASSIGNMENT SHEET #1

c. $\frac{1}{2}$, $\frac{9}{16}$, $\frac{3}{4}$, and $\frac{5}{32}$ = ______

d. $\frac{5}{6}$, $\frac{1}{12}$, $\frac{3}{16}$, and $\frac{17}{24}$ = ______

BASIC MATH
UNIT I

ASSIGNMENT SHEET #2--ADD AND SUBTRACT FRACTIONS

NAME ______________________ SCORE ____________

In the process of layout and machining the machinist must add or subtract dimensions found on the blueprint to obtain other dimensions. Show your work and reduce fractions.

1. Add the fractions below.

a. $\frac{1}{16} + \frac{5}{16} =$ ____

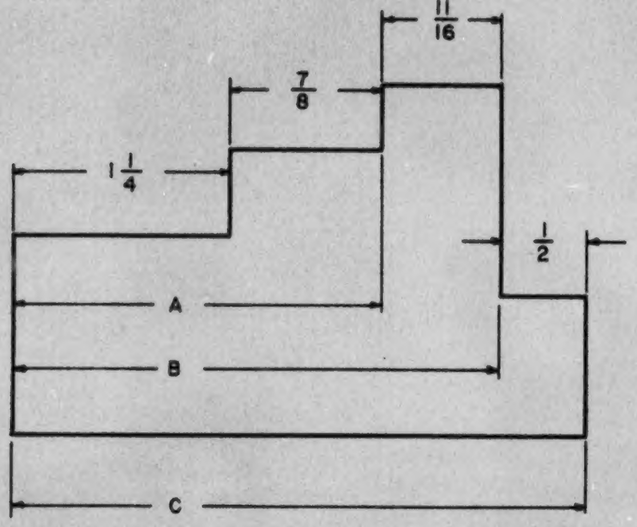
b. $\frac{1}{4} + \frac{3}{8} =$ ____

c. $2\frac{1}{2} + \frac{3}{4} =$ ____

d. $10\frac{5}{16} + 3\frac{1}{8} =$ ____

ASSIGNMENT SHEET #2

2. Determine the dimensions of a, b, and c.


11/16
7/8
1 1/4
1/2
A
B
C

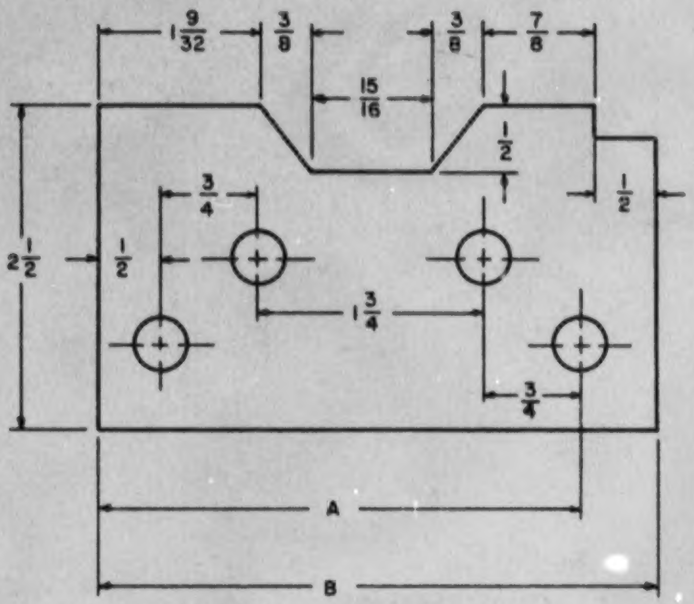
a. ____________

b. ____________

c. ____________

ASSIGNMENT SHEET #2

3. Determine the dimensions of a and b.


$1\frac{9}{32}$
$\frac{3}{8}$
$\frac{3}{8}$
$\frac{7}{8}$
$\frac{15}{16}$
$\frac{1}{2}$
$\frac{1}{2}$
$\frac{3}{4}$
$2\frac{1}{2}$
$\frac{1}{2}$
$1\frac{3}{4}$
$\frac{3}{4}$
A
B

a. ____________

b. ____________

4. Subtract the fractions below.

a. $\frac{5}{8} - \frac{9}{32} =$ ______

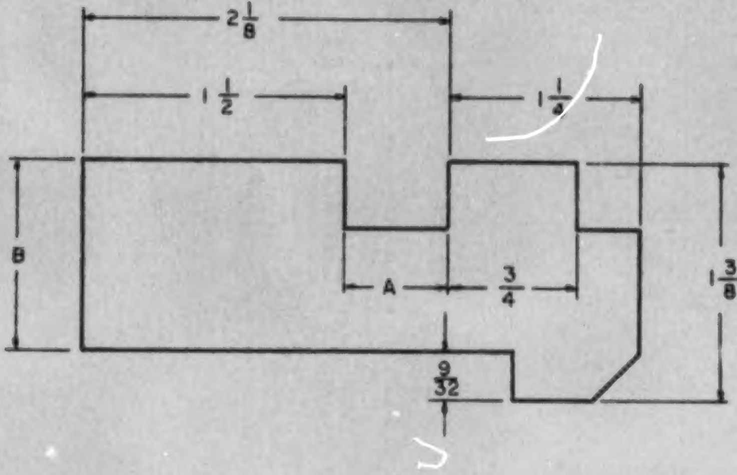
b. $1\frac{9}{16} - \frac{13}{16} =$ ______

c. $3\frac{9}{64} - 1\frac{7}{8} =$ ______

d. $\frac{7}{16} - \frac{5}{32} =$ ______.

ASSIGNMENT SHEET #2

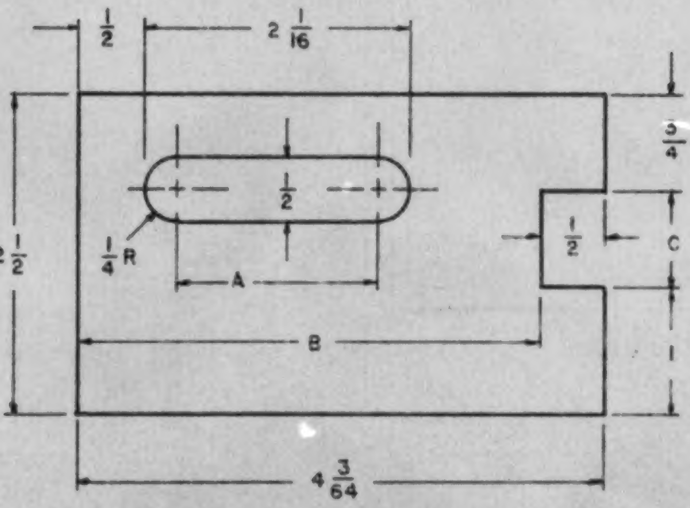
5. Determine the dimensions of a and b.


2 1/8
1 1/2
1 1/4
B
A
3/4
1 3/8
9/32

a. __________

b. __________

6. Determine the dimensions of a, b, and c.


1/2
2 1/16
1/2
1/4 R
A
2 1/2
3/4
1/2
C
B
4 3/64

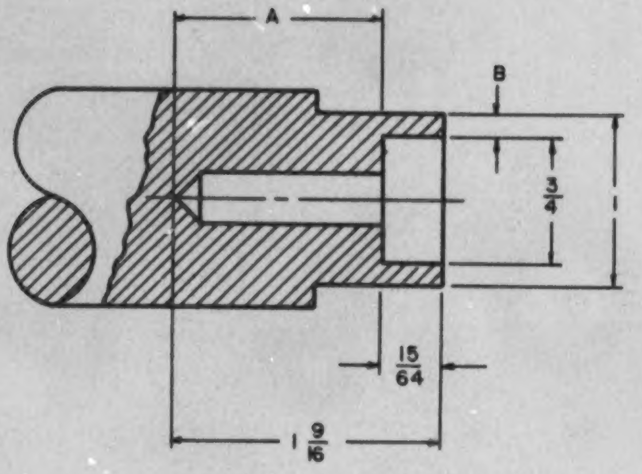
a. __________

b. __________

c. __________

ASSIGNMENT SHEET #2

7. Determine the dimensions of a and b.


A
B
3/4
15/64
1 9/16

a. ____________

b. ____________

BASIC MATH
UNIT I

ASSIGNMENT SHEET #3--MULTIPLY AND DIVIDE FRACTIONS

NAME ______________________________ SCORE ______________

Multiplication and division of fractions are necessary to determine the amount of stock required to make parts, production time, thread pitch, and distance between holes, just to name a few uses.

MULTIPLY FRACTIONS

1. Multiply the fractions below and reduce to lowest terms.

a. $\frac{1}{2} \times \frac{3}{4} =$ ____

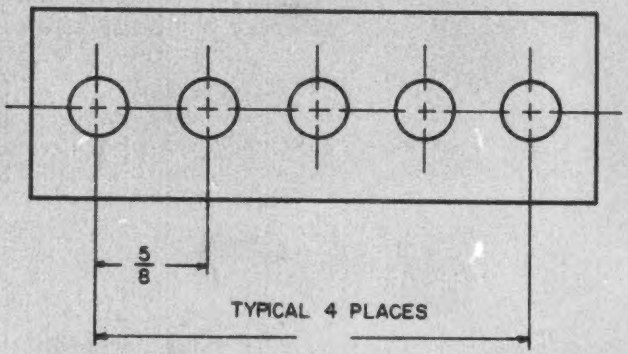
b. $\frac{3}{8} \times \frac{5}{16} =$ ____

c. $1\frac{1}{2} \times 2\frac{1}{4} \times \frac{1}{2} =$ ____

ASSIGNMENT SHEET #3

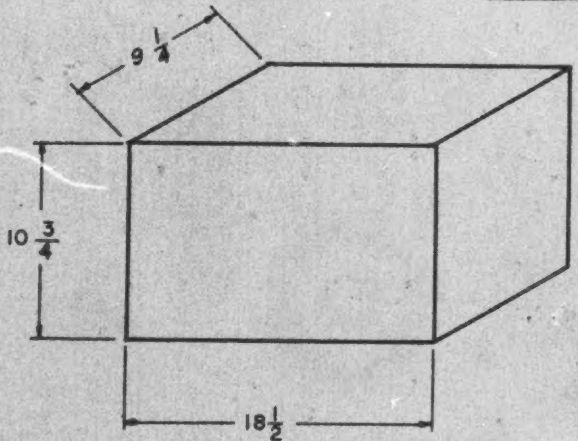
2. Determine the distance from the center of the first hole to the center of the last hole.

_____________________________ inches



3. To fill a coolant tank with a mixture of soluble oil you must first know the volume. If the inside of the tank measures 18 1/2 inches long, 9 1/4 inches wide, and 10 3/4 inches high, what is the volume? (Volume = length x width x height)

V = ____________________ cubic inches



ASSIGNMENT SHEET #3

DIVIDE FRACTIONS

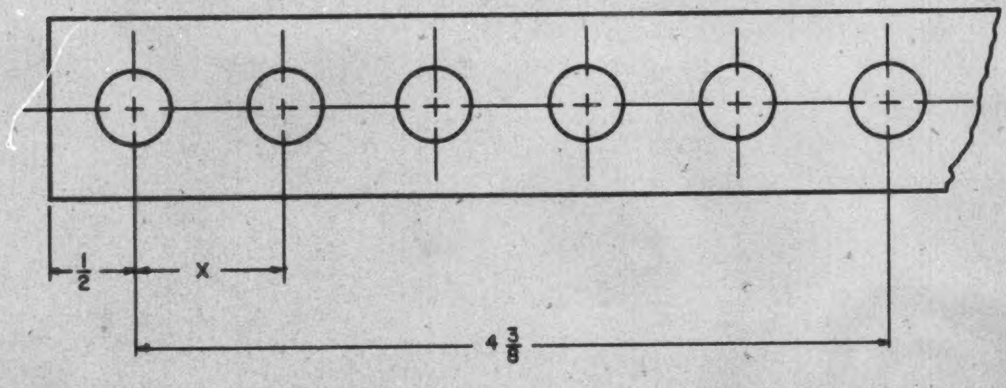
4. Divide the fractions below.

a. $\frac{7}{8} \div \frac{3}{4}$ = ______

b. $\frac{3}{4} \div 2$ = ______

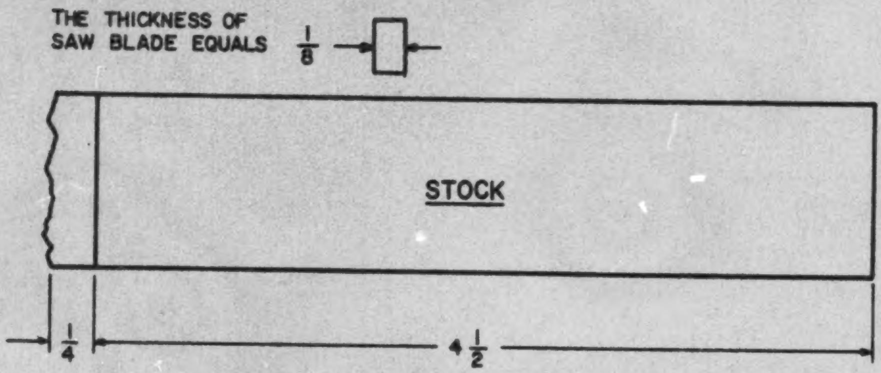
5. The strap pictured below needs 6 holes equally spaced. Determine the distance between the center of the holes.

______________________ inches



ASSIGNMENT SHEET #3

6. How many pieces of stock can I get from 2 bars of steel each 12 feet long, if the stock is finished at 4 1/2 inches long? (Add 1/4 inch for machining.)


THE THICKNESS OF SAW BLADE EQUALS 1/8
STOCK
1/4
4 1/2

BASIC MATH
UNIT I

ASSIGNMENT SHEET #4--CONVERT FRACTIONS AND DECIMAL FRACTIONS

NAME ______________________ SCORE __________

Converting fractions to decimals is an everyday job, and the more you work with them, the sooner you will learn the more commonly-used equivalents. Reading and writing decimals correctly helps you communicate with other workers.

1. Convert each of the following fractions to its decimal equivalent by dividing the denominator into the numerator. Correct to the fourth place.

Example: $\frac{1}{8} = .1250$

$$\begin{array}{r} .1250 \\ 8\overline{)\,1.0000} \\ \underline{8} \\ 20 \\ \underline{16} \\ 40 \\ \underline{40} \\ 0 \end{array}$$

a. $\frac{1}{64}$ = _____

b. $\frac{1}{32}$ = _____

c. $\frac{1}{16}$ = _____

ASSIGNMENT SHEET #4

d. $\frac{1}{4}$ = ____

e. $\frac{3}{16}$ = ____

f. $\frac{5}{16}$ = ____

g. $\frac{3}{8}$ = ____

h. $\frac{1}{2}$ = ____

i. $\frac{5}{32}$ = ____

j. $3\frac{5}{8}$ = ____

ASSIGNMENT SHEET #4

2. Write each decimal number.

   a. Sixty-two thousandths = ____________________

   b. Six hundred twenty-five thousandths = ____________________

   c. One and twenty-five thousandths = ____________________

   d. Eight and twenty-five ten thousandths = ____________________

   e. One and three thousandths = ____________________

3. Write out in words the following decimals:

   a. 3.50 ____

   b. .1250 ____

   c. 1.5 ____

   d. 125.062 ____

   e. 125.25 ____

BASIC MATH
UNIT I

ASSIGNMENT SHEET #5--ADD AND SUBTRACT DECIMAL FRACTIONS

NAME ______________________ SCORE ______________

Addition and subtraction of decimal fractions are required in every stage of machining.

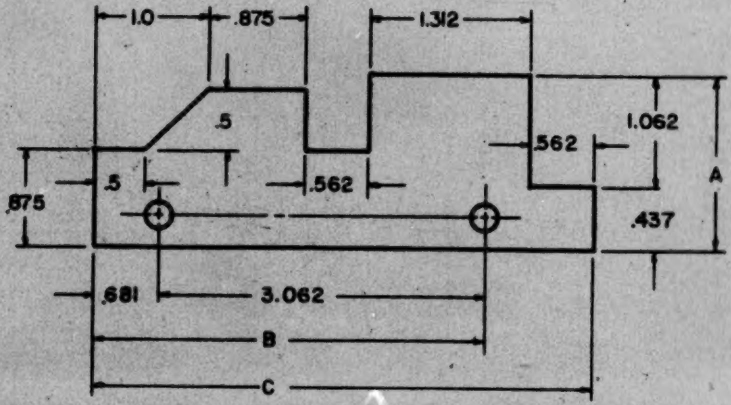
Determining length of cuts, location of slots and holes, layout and inspection are a few of the times you may need to perform this operation. Accuracy is the key to quality production of parts.

1. Add the following decimal fractions. Show your work.

a. .032 + .25 + 1.5 = ________

b. .0032 + 1.125 + .062 = ________

2. Determine dimensions of a, b, and c.



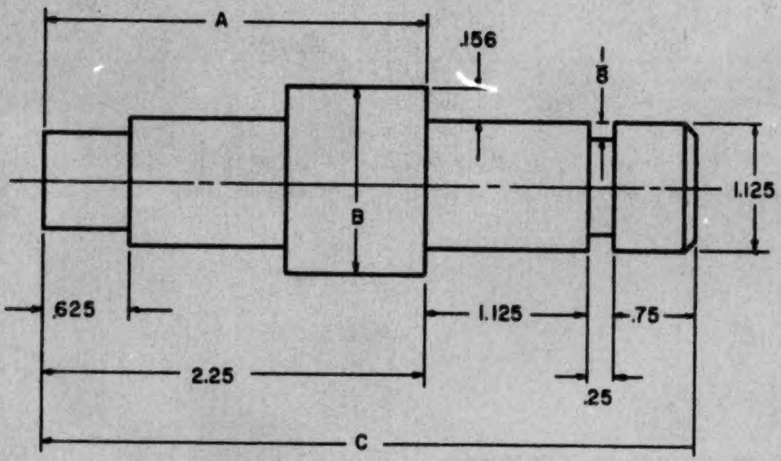
a. ____________

b. ____________

c. ____________

ASSIGNMENT SHEET #5

3. Determine dimensions of a, b, and c.


A
.156
1/8
B
1.125
.625
1.125
.75
2.25
.25
C

a. ____________

b. ____________

c. ____________

4. Subtract the following decimal fractions. Show your work.

a. 1.25 – .937 = ____________

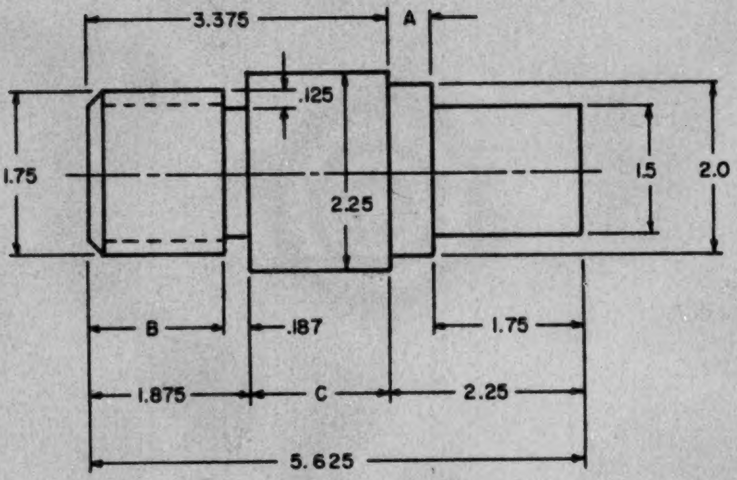
b. .951 – .087 = ____________

c. 1.0056 – .1875 = ____________

d. 10.4 – 3.625 = ____________

ASSIGNMENT SHEET #5

5. Determine dimensions of a, b, and c.

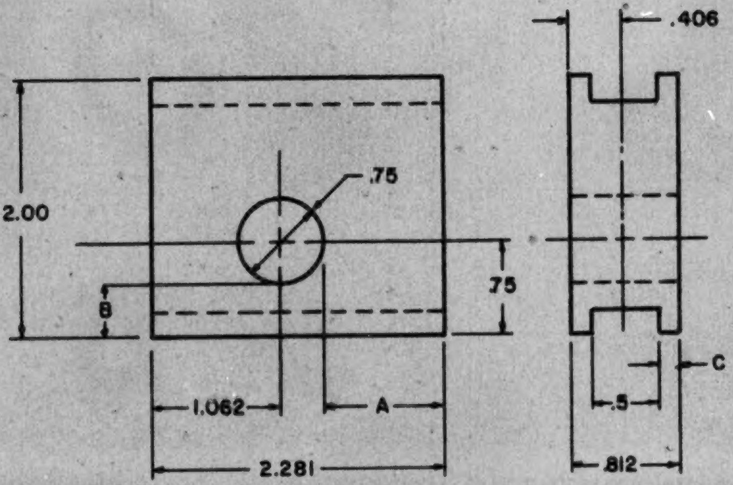

3.375
A
.125
1.75
2.25
1.5
2.0
B
.187
1.75
1.875
C
2.25
5.625

a. ____________

b. ____________

c. ____________

6. Determine dimensions of a, b, and c.


.406
2.00
.75
75
B
C
1.062
A
.5
2.281
.812

a. ____________

b. ____________

c. ____________

BASIC MATH
UNIT I

ASSIGNMENT SHEET #6--MULTIPLY DECIMAL FRACTIONS

NAME ______________________________ SCORE ______________

Machinists use multiplication of decimals in the calculating of shop math problems required to make a part.

1. Multiply the decimal fractions below. Show your work.

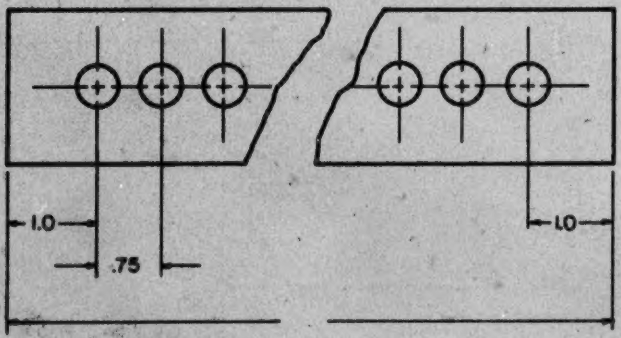
   a. 1.25 x .125 = ______________

   b. $\begin{array}{r} 12.062 \\ \underline{.937} \end{array}$

   c. $\begin{array}{r} 1.50 \\ \underline{.25} \end{array}$

   d. $\begin{array}{r} 16.5 \\ \underline{.3} \end{array}$

2. Determine the length of a steel bar that will have ten 1/2 inch holes with .75 inches center to center, plus 1.0 inches on each end. See the figure below.



L = ______________________________

BASIC MATH
UNIT I

ASSIGNMENT SHEET #7--DIVIDE DECIMAL FRACTIONS

NAME ______________________________ SCORE ____________

Division of decimals is frequently used by the machinist in the calculation of shop problems.

1. Divide the decimal fractions below. Show your work and carry your answers out to four places.

   a. .9375 ÷ .625 = ________

   b. 10.218 ÷ 2.05 = ________

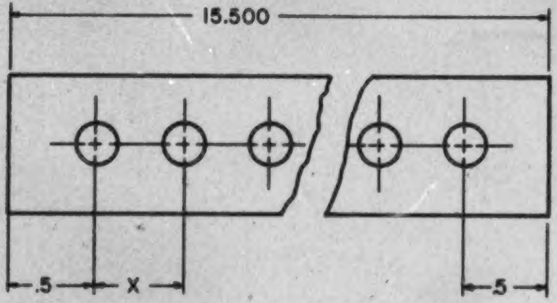
   c. .0625 ÷ 4 = ________

ASSIGNMENT SHEET #7

d. $1.5\overline{)1.0625}$ = ______ e. $.05\overline{)10.50}$ = ______

2. What is the center distance from hole to hole if a piece of bar stock 15.5" long is to have 15 holes equally spaced, drilled with the first and last hole arc .5" from end? (See the sketch below.)

x = ____________________



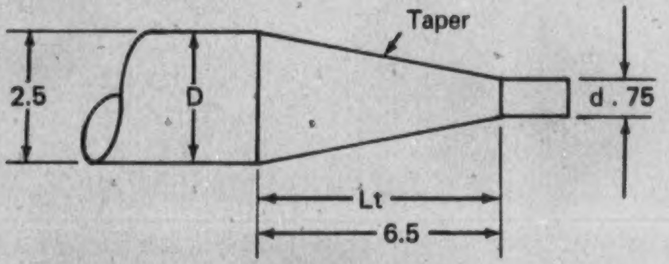
3. Calculate the taper to be machined; the formula is T.P.F. = $\frac{D - d}{Lt} \times 12$

Example:

T.P.F. = Taper Per Foot
D = Large end of the taper (Capital D)
d = Small end of the taper (Small d)
Lt = Length of the taper

$\frac{2.5 - .75}{6.5} \times 12 =$ ____________ T.P.F.

Illustration:



BASIC MATH
UNIT I

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

1. a. $\frac{3}{4}$
b. $\frac{1}{4}$
c. $\frac{7}{8}$
d. $\frac{1}{4}$

2. a. $\frac{4}{16}$
b. $\frac{20}{32}$
c. $\frac{6}{8}$
d. $\frac{56}{64}$

3. a. $\frac{15}{8}$
b. $\frac{167}{32}$
c. $\frac{5}{2}$
d. $\frac{67}{16}$

4. a. $2\frac{7}{8}$
b. $4\frac{1}{2}$
c. $7\frac{13}{16}$
d. $2\frac{5}{8}$

5. a. 32
b. 30
c. 32
d. 48

Assignment Sheet #2

1. a. $\frac{3}{8}$
b. $\frac{5}{8}$
c. $3\frac{1}{4}$
d. $13\frac{7}{16}$

2. a. $2\frac{1}{8}$
b. $2\frac{13}{16}$
c. $3\frac{5}{16}$

3. a. $3\frac{3}{4}$
b. $4\frac{11}{32}$

4. a. $\frac{11}{32}$
b. $\frac{3}{4}$
c. $1\frac{17}{64}$
d. $\frac{9}{32}$

5. a. $\frac{5}{8}$
b. $1\frac{3}{32}$

6. a. $1\frac{9}{16}$
b. $3\frac{35}{64}$
c. $\frac{3}{4}$

7. a. $1\frac{21}{64}$
b. $\frac{1}{8}$

Assignment Sheet #3

1. a. $\frac{3}{8}$
   b. $\frac{15}{128}$
   c. $1\frac{11}{16}$
2. $2\frac{1}{2}''$
3. $1839\frac{19}{32}$ c.i.
4. a. $1\frac{1}{6}$
   b. $\frac{3}{8}$
5. $\frac{7}{8}''$
6. 58 pieces

Assignment Sheet #4

1. a. .0156
   b. .0312
   c. .0625
   d. .2500
   e. .1875
   f. .3125
   g. .3750
   h. .5000
   i. .1562
   j. 3.6250
2. a. .062
   b. .625
   c. 1.025
   d. 8.0025
   e. 1.003
3. a. Three and fifty hundredths
   b. One thousand two hundred fifty ten-thousandths
   c. One and five tenths
   d. One hundred twenty-five and sixty-two thousandths
   e. One hundred twenty-five and twenty-five hundredths

Assignment Sheet #5

1. a. 1.782
   b. 1.1902
2. a. 1.499
   b. 3.743
   c. 4.311
3. a. 2.25
   b. 1.437
   c. 4.375
4. a. .313
   b. .864
   c. .8181
   d. 6.775
5. a. .500
   b. 1.688
   c. 1.500
6. a. .844
   b. .375
   c. .156

Assignment Sheet #6

1. a. .15625
   b. 11.302094
   c. .3750
   d. 4.95

2. 8.750

Assignment Sheet #7

1. a. 1.5000
   b. 4.9843
   c. .0156
   d. .7083
   e. 210.0000
2. 1.0357
3. 3.230

BASIC MATH
UNIT I

TEST

NAME ______________________________ SCORE ______________

1. Match terms associated with fractions and decimal fractions to their correct definitions. Write the correct numbers in the blanks provided.

_____a. The portion of the whole that is being considered; written above the line

_____b. Dividing both parts of a fraction by the same number in order to make it easier to read; does not change the value

_____c. Fraction that has been converted into a decimal

_____d. A whole number and a fraction that have been combined

_____e. A part of a whole; written as two numbers separated by a line

_____f. The numerator is larger than the denominator, making it larger than a whole unit

_____g. Tells the number of equal parts something is divided into; written below the line

_____h. The smallest number into which two or more denominators can be divided without leaving a remainder

_____i. One or more whole units

_____j. A fraction whose denominator is a power of 10, such as 10, 100, etc. The denominator is omitted and a decimal point is written to the left of the numerator with as many numbers to the right of the decimal point as there were 0's in the denominator

1. Fraction
2. Denominator
3. Numerator
4. Improper fraction
5. Mixed number
6. Reducing
7. Decimal fraction
8. Number
9. Decimal equivalent
10. Lowest common denominator

2. Reduce each of the following fractions to lowest terms.

a. $\frac{3}{6}$ = _______

b. $\frac{8}{32}$ = _______

c. $\frac{12}{16}$ = ____

d. $\frac{22}{64}$ = ____

e. $\frac{4}{16}$ = ____

f. $\frac{28}{32}$ = ____

3. Convert each of the following fractions to equivalent fractions. Write the correct numerator for each fraction.

a. $\frac{3}{4} = \frac{\quad}{32}$

b. $\frac{5}{8} = \frac{\quad}{16}$

c. $\frac{3}{16} = \frac{\quad}{64}$

d. $\frac{1}{3} = \frac{\quad}{30}$

e. $\frac{1}{2} = \frac{\quad}{32}$

f. $\frac{5}{32} = \frac{\quad}{64}$

4. Change the following mixed numbers to improper fractions. Write the correct numbers in the blanks provided.

a. $5\frac{3}{32}$ =

b. $1\frac{1}{2}$ = ____

c. $3\frac{3}{8}$ = ____

d. $2\frac{3}{4}$ = ____

e. $1\frac{2}{3}$ = ____

f. $2\frac{3}{16}$ = ____

5. Change each of the following improper fractions to mixed numbers. Reduce fractions to lowest terms.

a. $\frac{21}{8} =$ _____ b. $\frac{22}{4} =$ _____ c. $\frac{91}{16} =$ _____

d. $\frac{84}{32} =$ _____ e. $\frac{17}{2} =$ _____ f. $\frac{17}{9} =$ _____

6. Determine the lowest common denominator for the following fractions.

a. $\frac{1}{2}, \frac{3}{8}, \frac{1}{16} =$ _____

b. $\frac{3}{16}, 1\frac{1}{2}, \frac{5}{32} =$ _____

c. $\frac{3}{4}, \frac{1}{4}, 2\frac{1}{2} =$ _____

7. Add the following fractions and reduce if necessary.

a. $\frac{3}{4} + \frac{1}{2} + \frac{5}{16} =$ _____

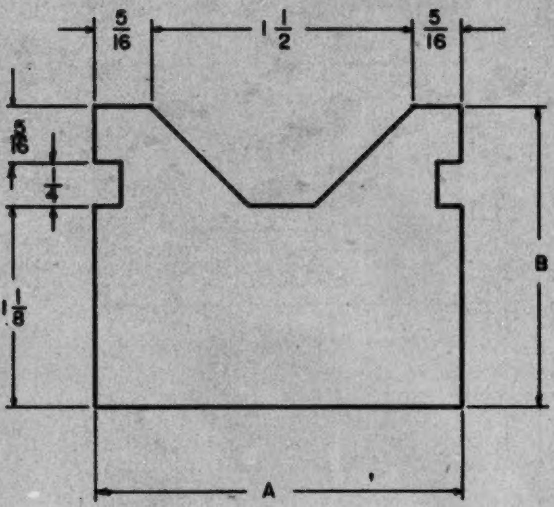
b. $\frac{7}{8} + \frac{1}{4} + 1 =$ _____

c. $\frac{1}{2} + 1\frac{1}{4} + \frac{3}{16} =$ _____

d. $\frac{9}{32} + \frac{5}{8} + 2\frac{1}{2} =$ _____

e. $\frac{5}{16} + 1\frac{1}{32} + \frac{3}{8} =$ _____

f. Determine the dimensions of A and B. Reduce fractions to lowest terms, and write the correct answers in the blanks provided.



A. ________

B. ________

8. Subtract the following fractions and reduce to lowest terms.

a. $\frac{15}{16} - \frac{3}{4} =$ ____

b. $\frac{21}{32} - \frac{1}{2} =$ ____

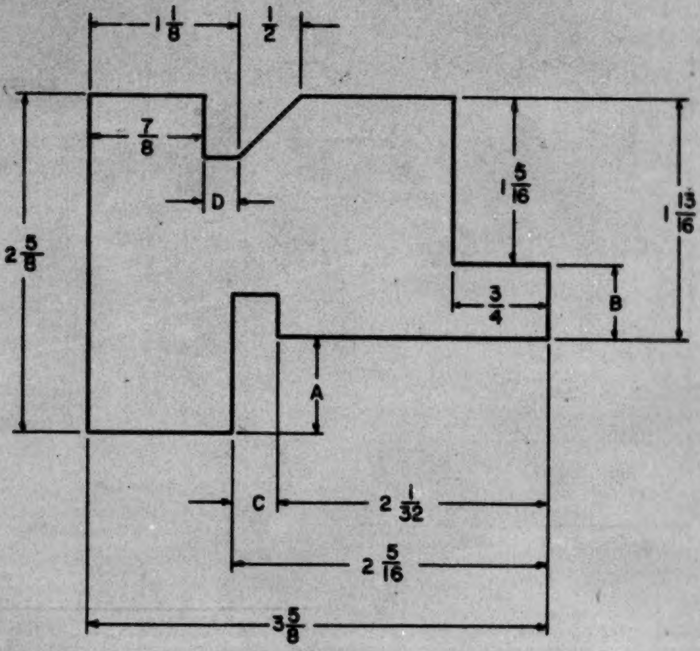
c. $3\frac{5}{8} - 1\frac{9}{32} =$ ____

d. $1\frac{3}{16} - \frac{15}{32} =$ ____

e. $2\frac{1}{2} - \frac{3}{16} =$ ____

f. $\frac{1}{2} - \frac{3}{32} =$ ____

g. Determine the dimensions A, B, C, and D. Reduce the fractions to lowest terms and write the correct answers in the blanks provided.


$1\frac{1}{8}$
$\frac{1}{2}$
$\frac{7}{8}$
D
$2\frac{5}{8}$
$1\frac{5}{16}$
$1\frac{13}{16}$
$\frac{3}{4}$
B
A
C
$2\frac{1}{32}$
$2\frac{5}{16}$
$3\frac{5}{8}$

A. ______

B. ______

C. ______

D. ______

9. Multiply the following fractions and reduce to lowest terms.

a. $\frac{1}{2} \times \frac{3}{4} =$ ______

b. $1\frac{1}{16} \times \frac{5}{8} =$ ______

c. $\frac{5}{8} \times 1\frac{1}{4} \times \frac{3}{1} =$ ______

d. $\frac{3}{8} \times \frac{1}{4} =$ ______

e. Find the volume of a rectangular coolant tank that measures on the inside 15 3/4" long, 10 1/2" wide, and 12 1/2" deep.

Volume = length x width x height or V = ________ cubic inches

10. Divide fractions and change to simplest form.

a. $\frac{3}{4} \div \frac{1}{2} =$ ____

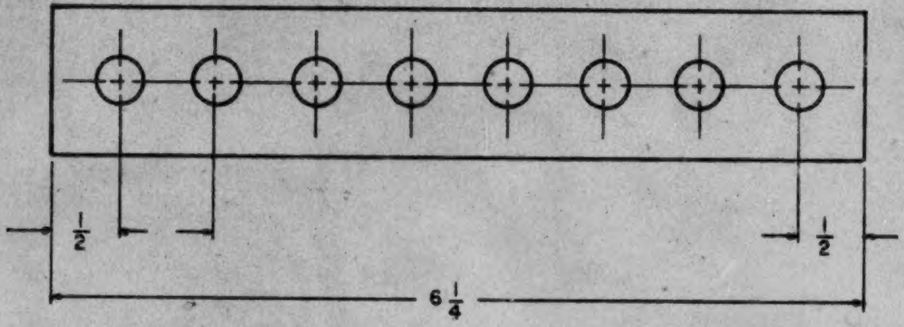
b. $1\frac{1}{2} \div \frac{7}{8} =$ ____

c. $4\frac{3}{8} \div 5 =$ ____

d. $\frac{7}{8} \div \frac{1}{16} =$ ____

e. Find the spacing between the holes in the diagram below so that eight holes are equally spaced.

____________________ inches



11. Construct the decimal number system. Assume that the letters below stand for a number; write the decimal place indicated in the blanks provided.

A B C D . E F G H I J

a. ____________________

b. ____________________

c. ____________________

d. ____________________

e. ____________________

f. ____________________

g. ____________________

h. ____________________

i. ____________________

j. ____________________

12. Write the decimal fraction for each of the following:

a. Three tenths = __________

b. Twenty-five thousandths = __________

c. Six thousand two hundred fifty-seven ten-thousandths = __________

13. Convert each of the following fractions to decimal fraction equivalents. Carry your answer to the fourth place.

Example: $\frac{1}{4} = .2500$

(NOTE: Do not round off.)

a. $\frac{3}{4} =$ ______

b. $\frac{7}{32} =$ ______

c. $\frac{5}{16} =$ ______

d. $2\frac{1}{16} =$ ______

e. $\frac{15}{16} =$ ______

14. Write each of the following decimal fractions out in words.

a. .001 = ____

b. .6258 = ____

c. 10.250 = ____

15. Add or subtract the following decimal fractions as indicated.

a. 1.5 + .250 + 3 + .0065 = __________

b. 1.75 − 1.218 = __________

c. 0.001 + 1.05 + 2.5 = __________

d. 2.25 – 1.8750 = __________

e. 1.156 + .531 = __________

16. Multiply the following decimal fractions.

a. 1.625 x 2.5 = __________

b. 1.562 x .312 = __________

c. 1.5 x 2.875 x 2 = __________

d. 3.6258 x 1.1875 = __________

e. .0251 x .05 = __________

17. Divide decimal fractions. Carry all problems to the fourth decimal place. Do not round off.

a. 20.05 ÷ 1.5 = __________ b. .0625 ÷ .05 = __________

c. 2.562 ÷ .937 = __________ d. 2.562 ÷ 1.0625 = __________

e. 4.6258 ÷ .093 = __________

BASIC MATH
UNIT I

ANSWERS TO TEST

(NOTE: The point system designated in parentheses is intended to be a guideline and should be adapted as needed. The point total is 200.)

1. (20 points)
   - a. 3
   - b. 6
   - c. 9
   - d. 5
   - e. 1
   - f. 4
   - g. 2
   - h. 10
   - i. 8
   - j. 7
2. (12 points)
   - a. $\frac{1}{2}$
   - b. $\frac{1}{4}$
   - c. $\frac{3}{4}$
   - d. $\frac{11}{32}$
   - e. $\frac{1}{4}$
   - f. $\frac{7}{8}$
3. (12 points)
   - a. $\frac{24}{32}$
   - b. $\frac{10}{16}$
   - c. $\frac{12}{64}$
   - d. $\frac{10}{30}$
   - e. $\frac{16}{32}$
   - f. $\frac{10}{64}$

4. (12 points)

   a. $\frac{163}{32}$

   b. $\frac{3}{2}$

   c. $\frac{27}{8}$

   d. $\frac{11}{4}$

   e. $\frac{5}{3}$

   f. $\frac{35}{16}$

5. (12 points)

   a. $2\frac{5}{8}$

   b. $5\frac{1}{2}$

   c. $5\frac{11}{16}$

   d. $2\frac{5}{8}$

   e. $8\frac{1}{2}$

   f. $1\frac{8}{9}$

6. (6 points)

   a. 16

   b. 32

   c. 4

7. (14 points)

   a. $1\frac{9}{16}$

   b. $2\frac{1}{8}$

   c. $1\frac{15}{16}$

   d. $3\frac{13}{32}$

   e. $1\frac{23}{32}$

   f. Dimension A- $2\frac{1}{8}$

      Dimension B- $1\frac{11}{16}$

8. (20 points)

a. $\frac{3}{16}$

b. $\frac{5}{32}$

c. $2\frac{11}{32}$

d. $\frac{23}{32}$

e. $2\frac{5}{16}$

f. $\frac{13}{32}$

g. A= $\frac{13}{16}$

B= $\frac{1}{2}$

C= $\frac{9}{32}$

D= $\frac{1}{4}$

9. (10 points)

a. $\frac{3}{8}$

b. $\frac{85}{128}$

c. $2\frac{11}{32}$

d. $\frac{3}{32}$

e. $2067\frac{3}{16}$ cu. in.

10. (10 points)

a. $1\frac{1}{2}$

b. $1\frac{5}{7}$

c. $\frac{7}{8}$

d. 14

e. $\frac{3}{4}$"

11. (20 points)

a. Thousands

b. Hundreds

c. Tens

d. Units

e. Tenths

f. Hundredths

g. Thousandths

h. Ten-thousandths

i. Hundred-thousandths

j. Millionths

12. (6 points)
    a. .3
    b. .025
    c. .6257

13. (10 points)
    a. .7500
    b. .2187
    c. .3125
    d. 2.0625
    e. .9375

14. (6 points)
    a. One thousandth
    b. Six thousand two hundred fifty-eight ten thousandths
    c. Ten and two hundred fifty thousandths

15. (10 points)
    a. 4.7565
    b. .532
    c. 3.551
    d. .3750
    e. 1.687

16. (10 points)
    a. 4.0625
    b. .487344
    c. 8.6250
    d. 4.30663750
    e. .001255

17. (10 points)
    a. 13.3666
    b. .1250
    c. 2.7342
    d. 2.4112
    e. 49.7397

BLUEPRINTS
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student will be able to interpret blueprint symbols, lines, and abbreviations. The student should also be able to construct views using orthographic projections and read industrial blueprints. This knowledge will be evidenced by completion of assignment sheets and unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with blueprints to the correct definitions.
2. Match symbols used on blueprints to the correct meanings.
3. Write abbreviations used on blueprints.
4. Identify the blueprint alphabet of lines.
5. Sketch orthographic projection drawings.
6. Label types of views shown on a blueprint.
7. Define dimension and tolerance.
8. Identify industry methods of showing dimension and tolerance.
9. Select from a list types of information found in a blueprint title block.
10. Interpret machine specifications and processes on blueprints.
11. Read industrial blueprints.

9. Assignment Sheet #9--Read Blueprints

10. Assignment Sheet #10--Read an Industrial Blueprint

III. Unit references:

A. Olivo, Dr. C.; Payne, Albert V.; and Olivo, Thomas P. *Basic Blueprint Reading and Sketching.* Albany, New York: Delmar Publishers, 1978.

B. *Military Standard Dimensioning and Tolerancing.* MIL-STD-8C. U.S.: October 16, 1963.

C. *Math, Blueprint Reading, Measuring Tools*, rev. ed. Stillwater, Oklahoma: State Department of Vocational and Technical Education/Curriculum and Instructional Materials Center, 1975.

BLUEPRINTS
UNIT II

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

   A. Provide students with objective sheet and make transparency.

   B. Provide students with information and assignment sheets.

   C. Discuss unit and specific objectives.

   D. Discuss information and assignment sheets.

   E. Collect industrial blueprints from local industries to stress the need for learning to read blueprints correctly.

   F. Obtain a collection of parts and their blueprints.

   G. Provide graph paper for students.

   H. Give test.

   I. Reteach and retest if necessary.

II. Instructional materials:

   A. Objective sheet

   B. Information sheet

   C. Transparency Master #1--Title Block

   D. Assignment sheets

      1. Assignment Sheet #1--Match Blueprint Symbols to Their Definitions

      2. Assignment Sheet #2--Write Meanings of Abbreviations used on Blueprints

      3. Assignment Sheet #3--Identify Lines on Blueprints

      4. Assignment Sheet #4--Complete Orthographic Projection Drawings

      5. Assignment Sheet #5--Identify Other Views of Blueprints

      6. Assignment Sheet #6--Locate Information on the Title Block

      7. Assignment Sheet #7--Sketch Orthographic Projections

      8. Assignment Sheet #8--Identify Machining Specifications and Processes

BLUEPRINTS
UNIT II

INFORMATION SHEET

I. Terms and definitions

A. Anneal--The process of heating a metal piece to a high temperature to soften it, and allowing it to cool slowly

B. Bearing--A support for a shaft or pivot

C. Bevel--A surface that is tapered at an angle other than a right angle to a reference surface

D. Bore--A hole that is usually cut by using a boring tool; the surface is usually a locating surface

E. Boss--A circular projection on a casting

F. Carburize--Preparation process for tempering steel

(NOTE: Low carbon steel is heated in a carbonizing material and then cooled slowly so that carbon is absorbed into the surface of the metal.)

G. Case harden--The process of hardening the outer surface of a steel part, forming a hard case on the metal while leaving the inner metal soft

H. Chamfer--To remove a sharp external edge with a cutting tool, usually at an angle of 45° and a depth of .030 inch or less

I. Counterbore--The process of enlarging a portion of a hole to a specific diameter and depth, usually greater than .030 inch

J. Countersink--The process of tapering the top of a hole at a specific angle

K. Crown--An angular or rounded contour often found on the face of a pulley

L. Drill--The process of originating a hole by using a drill

M. Concentric--Circles lying in the same plane with the same center

N. Eccentric--Circles lying in the same plane which partly coincide but do not have the same center

O. Fillet--A curved inside corner formed to increase the strength of an object and improve its appearance

P. Flange--A projecting rim used for fastening or increasing strength

INFORMATION SHEET

Q. Grind--The process of finishing machined parts by means of a revolving abrasive wheel

R. Keyway--A slot cut on a shaft or in the bore of a gear or pulley, into which is fitted a key

S. Pad--Square or circular raised surface found on castings

T. Knurl--A series of small diamond-shaped or straight impressions pressed into a metal surface

U. Lap--The process of lapping finished parts to very close tolerances, leaving the surface very smooth

V. Neck--The process of cutting a relief in a diameter near a shoulder

W. Parallel--Two or more surfaces that are the same distance apart at all points

X. Ream--The process of finishing a drilled hole to an accurate size

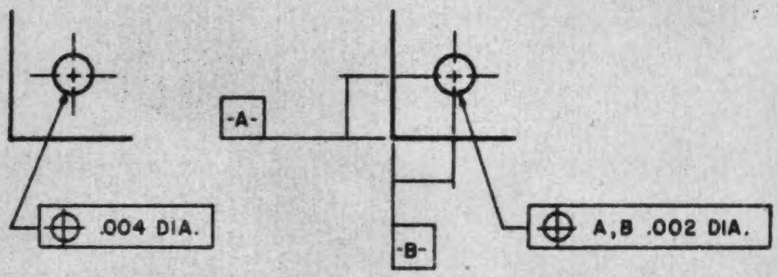
Y. Spot face--The process of making a flat surface perpendicular to a specific diameter and depth, usually less than .030 inch

II. Symbols used on blueprints (Assignment Sheet #1)

A. ⌖ --True position

(NOTE: True position is usually indicated on a blueprint to show size or location to datum lines.)

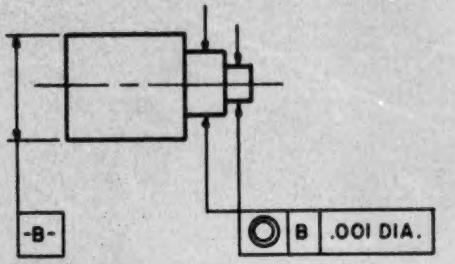
Example:



INFORMATION SHEET

B. ◎ --Concentricity

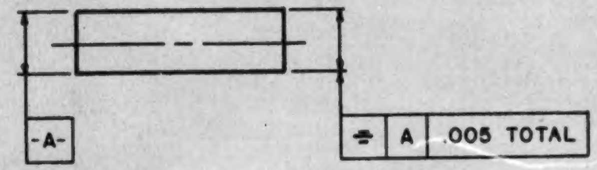
(NOTE: Centers of turned areas must be within certain limits of a common axis.)



C. ⌯ --Symmetry

(NOTE: Symmetry is a balance in arrangement.)

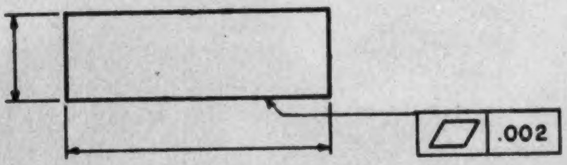
Example:



D. ▱ --Flatness

(NOTE: A flat surface must be flat within a certain tolerance.)

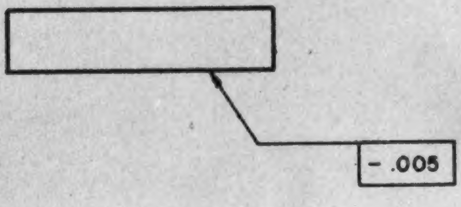
Example:



E. —— --Straightness

(NOTE: Surface must be straight within a certain tolerance.)

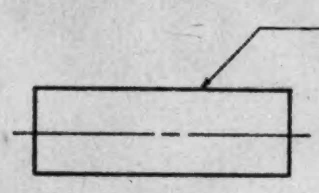
Example:



INFORMATION SHEET

F. ○ --Roundness

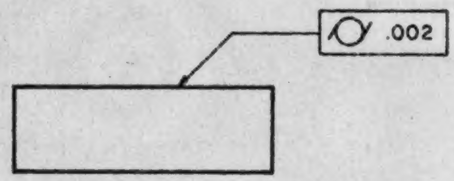
Example:



G. ⌭ --Cylindricity

(NOTE: Surface must be round and straight within certain limits.)

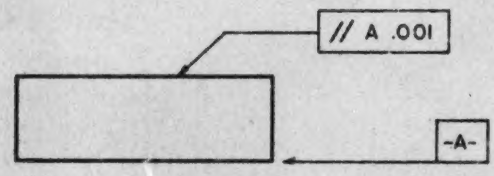
Example:



H. // --Parallelism

(NOTE: Surface must be parallel to another surface within certain limits.)

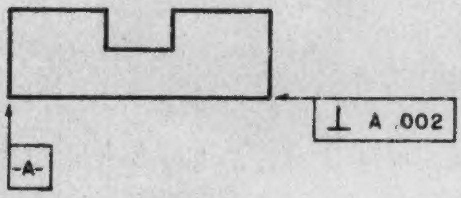
Example:



I. ⊥ --Perpendicularity

(NOTE: Surface must be 90° to reference within certain limits.)

Example:

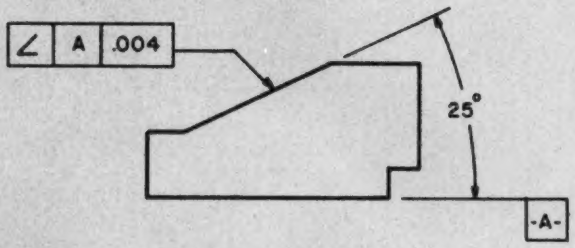


INFORMATION SHEET

J. ∠ --Angularity

(NOTE: Angles must be within a certain tolerance to a reference line.)

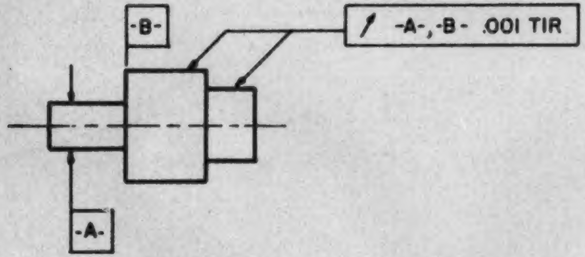
Example:



K. ↗ --Runout

(NOTE: Runout tells how true one surface must be with another.)

Example:

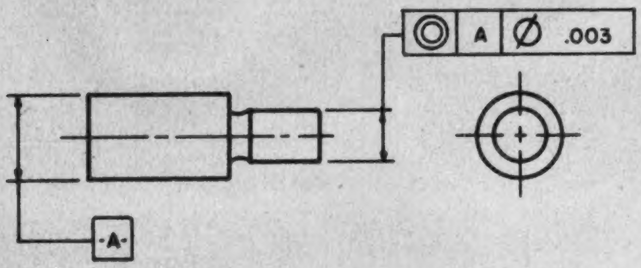


Round surfaces are true to the same center axis within certain limits

(NOTE: All these symbols refer to tolerance of something to something. Other abbreviations may be added to the boxes [TIR] Total Indication Reading.)

L. ∅ --Diameter

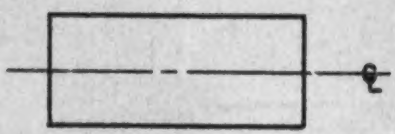
(NOTE: Diameter is used with a number to indicate the size or tolerance of diameter.)



INFORMATION SHEET

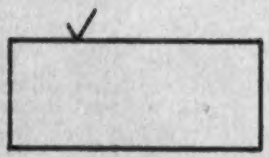
M. ℄ --Center line

Example:



N. ✓ --Surface finish

Example:



III. Abbreviations used on blueprints (Assignment Sheet #2)

A. CI--Cast iron

B. CRS--Cold rolled steel

C. CS--Cast steel

D. CC--Center to center

E. C' Bore or CB--Counterbore

F. Csk--Countersink

G. Dia--Diameter

H. F or Fin--Finish

I. FAO--Finish all over

INFORMATION SHEET

J. SQ--Square

K. FS--Full size

L. FSD--Full size detail

M. Hex--Hexagon

N. ID--Inside diameter

O. OD--Outside diameter

P. No--Number

Q. OC--On center

R. R or Rad--Radius

S. Req'd or Req--Required

T. SAE--Society of Automotive Engineers

U. AISI--American Iron and Steel Institute

V. USS--United States Standard

W. PD--Pitch diameter

X. Rd--Round

Y. SYM--Symmetrical

Z. TIR--Total indicator reading

AA. TYP--Typical

BB. Par--Parallel

CC. UNC--United National Coarse

DD. UNF--Unified National Fine

EE. UNS--Unified National Special

FF. UNEF--Unified National Extra Fine

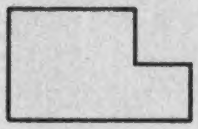
GG. NTP--American Standard Taper Pipe

INFORMATION SHEET

IV. Blueprint alphabet of lines (Assignment Sheet #3)

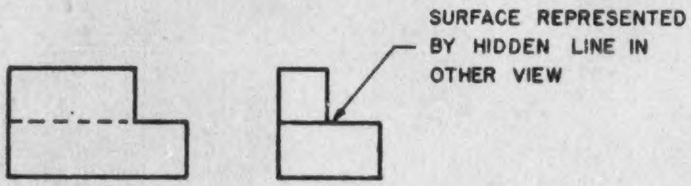
A. Object lines--Show the outline of the part that would be visible when viewing the part from a particular position; they are usually the thickest solid lines on a blueprint (————)

Example:



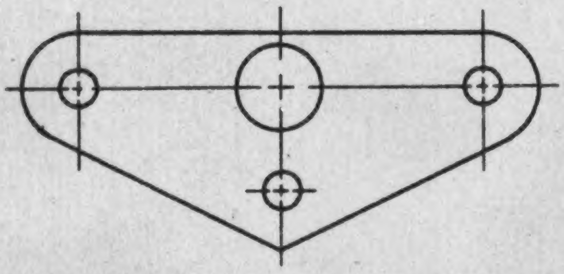
B. Hidden lines--Lines that show edges, surfaces, and corners which are not visible in that particular view; medium weighted short dashed lines (-------)

Example:



C. Center line–Used to designate centers of symmetrical objects, holes, and arcs; thin broken line of long-short-long dashes (———— — ————)

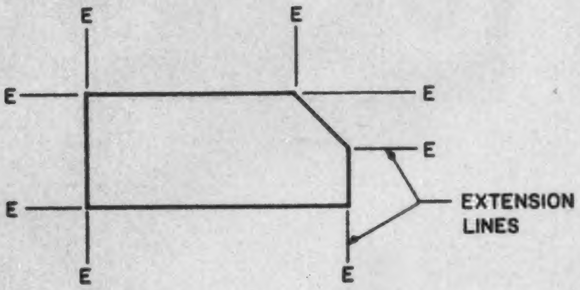
Example:



INFORMATION SHEET

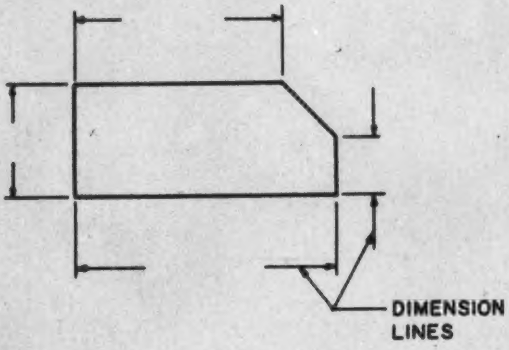
D. Extension line--Used in dimensioning to show size of an object; is a light unbroken line (————)

Example:


E
E
E
E
E
E
E
E
EXTENSION LINES

E. Dimension lines--Light lines with arrowheads at each end; heads of the arrows terminate at extension lines; dimensions are placed at breaks in the line (←— —→)

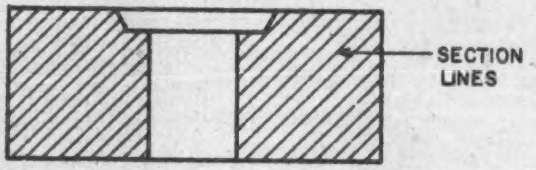
Example:


DIMENSION LINES

INFORMATION SHEET

F. Section lines--Thin lines usually drawn at a 45° angle indicating the cut surface of an object in a section view; also denote the material of the object

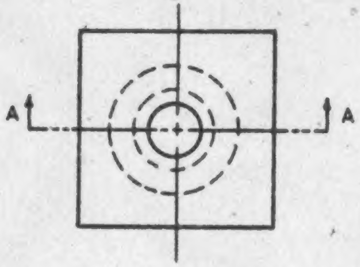
Example:

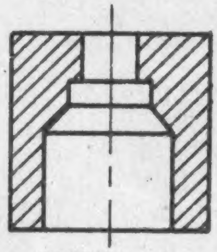


G. Cutting plane line--Used to show something that would not be clear on a regular view; a thick line with a long and two short dashes, having short 90° lines at the ends ending with arrows (A ↑‒‒ ‒‒‒‒‒ ‒‒↑)

(NOTE: Those 90° lines show the direction of sight for viewing the section, and the letters are used to indicate the section.)

Examples:



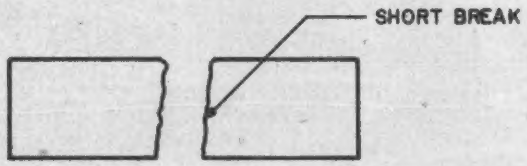


SECTION AA

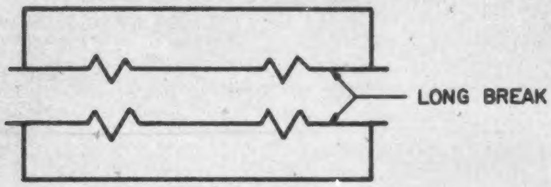
INFORMATION SHEET

H. Break lines--Used for indicating a part too long to place on the drawing

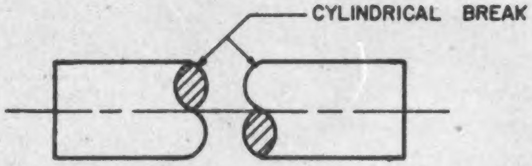
1. Short break


SHORT BREAK

2. Long break

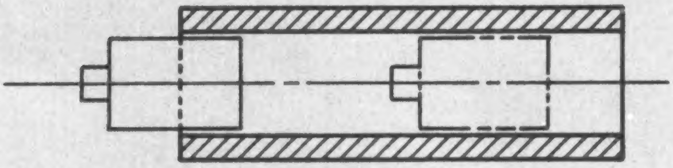


3. Cylindrical break


CYLINDRICAL BREAK

I. Phantom line--Used primarily to indicate alternate positions of moving parts, position of related part, or related detail; is a thin line of long and two short alternating dashes (———--———--—)

Example:



INFORMATION SHEET

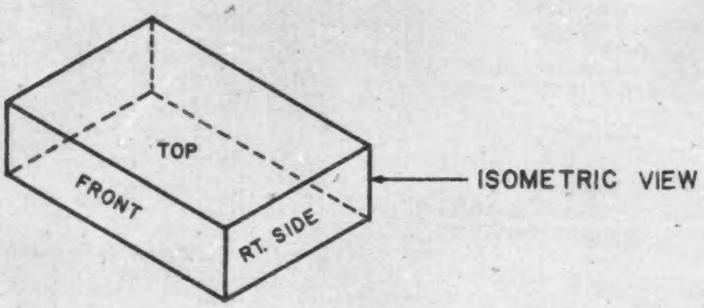
V. Orthographic projection drawings (Assignment Sheets #4 and #7)

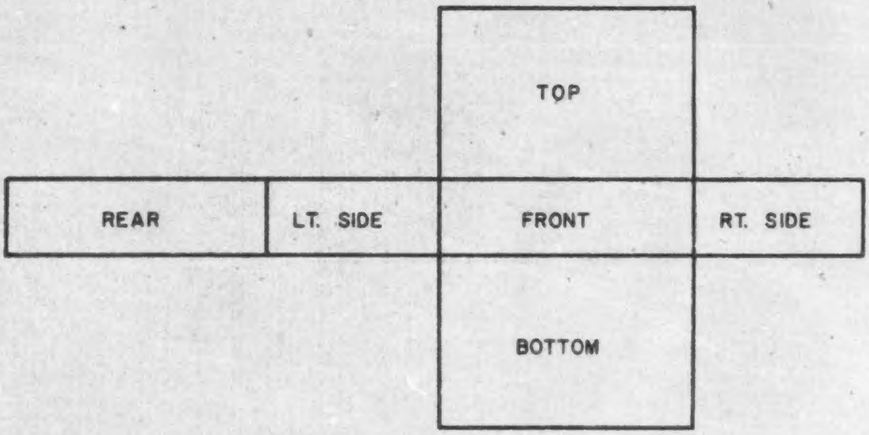
A. Are multiview drawings that show every feature of an object in size and shape

B. Help the user form a mental picture (isometric view) of the object because views are arranged in a systematic way

(NOTE: Two- and three-view drawings are usually all that are required to show size, shape, and most details of parts to be machined.)

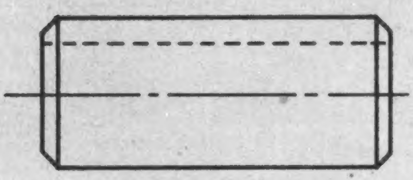
Example: If you were to take a box and label the sides and then cut the box and unfold it you would have these six views


TOP
FRONT
RT. SIDE
ISOMETRIC VIEW

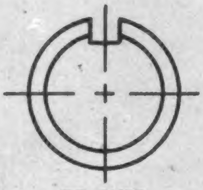

TOP
REAR
LT. SIDE
FRONT
RT. SIDE
BOTTOM

INFORMATION SHEET

C. Two-view drawings--Used with round or square objects; only the front and right side views are pictured because the other views of the part would be the same



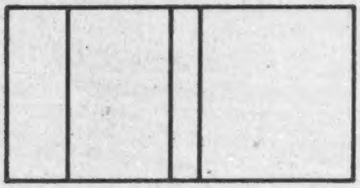
FRONT

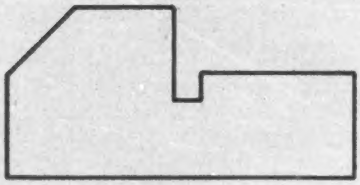


RT. SIDE

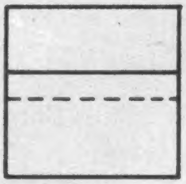
D. Three-view drawings--Used for three or more surfaces; usually pictured are the front, top, and right side views

TOP





FRONT



RIGHT SIDE

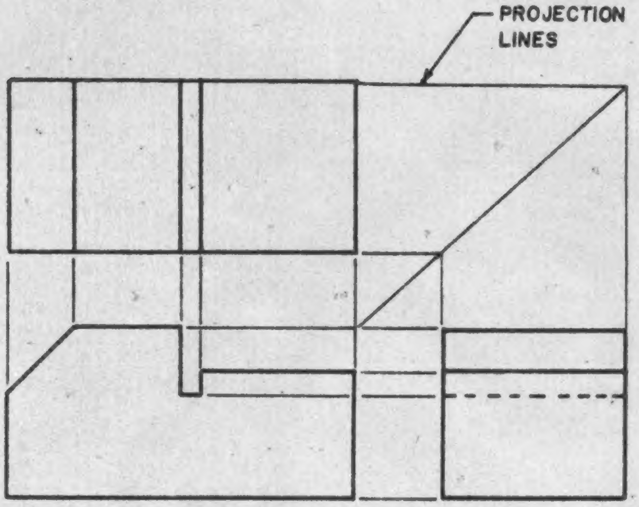
(NOTE: These parts are arranged systematically with respect to each other; this is still the box with six sides, but only three of the sides are used.)

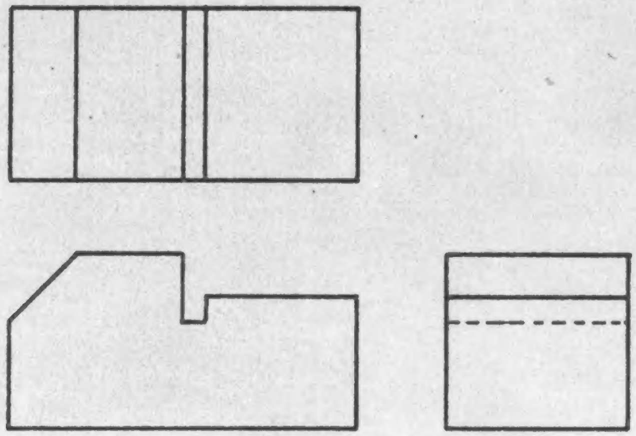
INFORMATION SHEET

E. Help establish the relationship of lines and surfaces in one view to lines and surfaces in other views by use of projection lines

(NOTE: Projection lines do not appear on finished blueprint.)

Example:





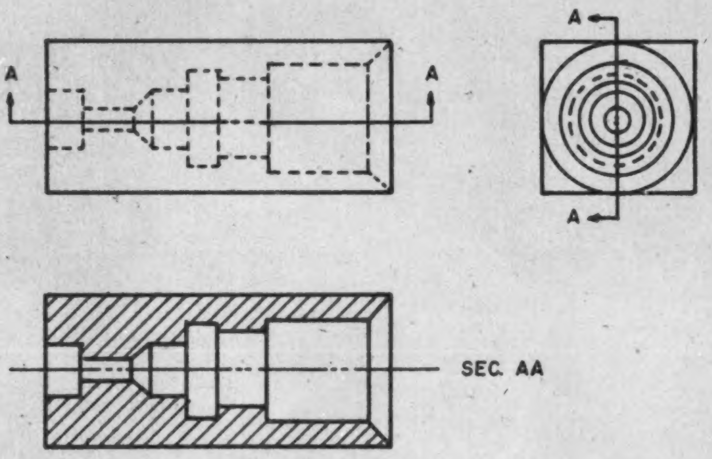
INFORMATION SHEET

VI. Types of views found on a blueprint (Assignment Sheet #4)

(NOTE: In some cases it is necessary to show views other than the standard six views to make the picture of the object clear to the user.)

A. Section view--Inside detail of an object that is cut with a cutting plane line; helps clear up the hidden lines that may make the drawing difficult to interpret

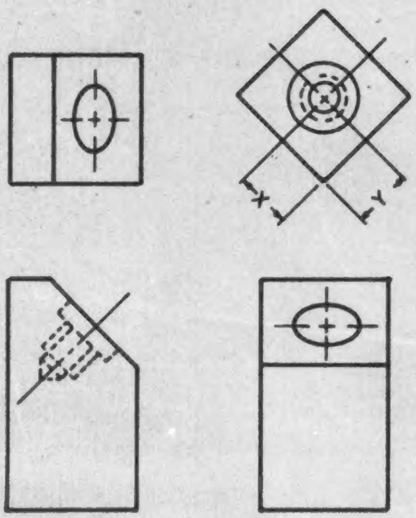
Example:



B. Auxiliary view--Shows the shape and size of an object that cannot be shown with clarity in the regular view

(NOTE: Auxiliary views are also used for dimensioning.)

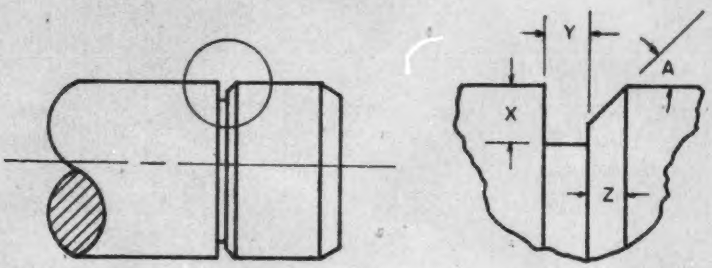
Example:



INFORMATION SHEET

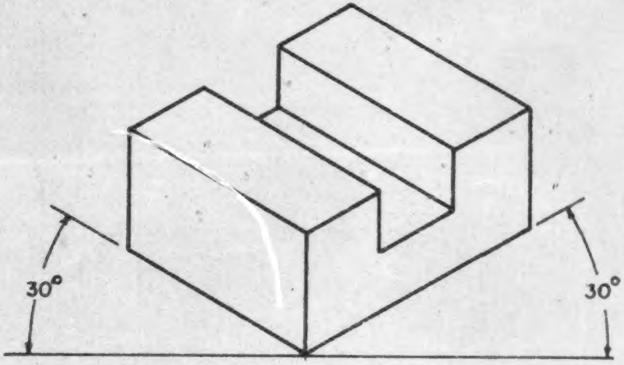
C. Detail view--Focuses in on a particular section of a drawing; is usually enlarged several times for clarification

Example:



D. Isometric view--Shows the part in 3 dimensions, usually the front, side, and top views

Example:



VII. Dimension and tolerance

A. Dimension--Tells the size, shape, and location of holes and slots

(NOTE: Depending on the industry, the draftsperson's preference is used on the part as to the type of dimensioning used.)

B. Tolerance--The total variation permitted in the size of a part

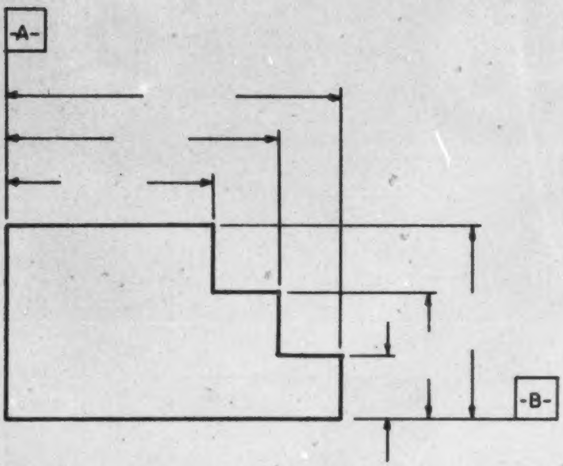
INFORMATION SHEET

VIII. Industry methods of showing dimension and tolerance (Assignment Sheet #7)

A. Dimension

1. Datums--Points, surfaces or lines from which references are made; indicated by letters with dashes on each side and enclosed in a small box

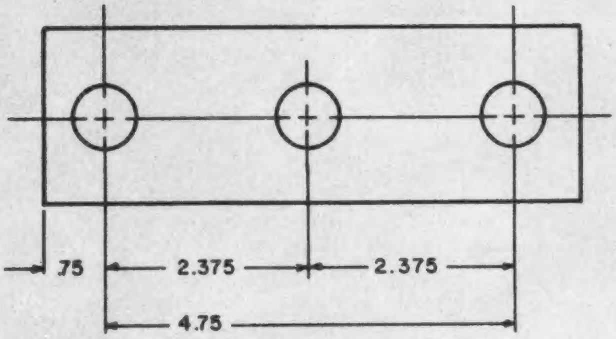
Example:



(NOTE: All dimensions are referenced from A and B datum lines.)

2. Linear dimensioning--Method of referencing dimensions where accurate machining is required

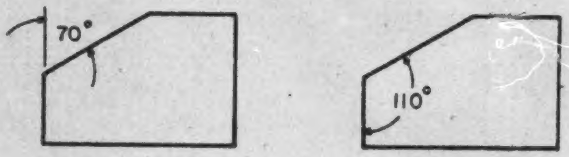
Example:



INFORMATION SHEET

3. Angular dimensions--Used to indicate the size of angles in degrees, minutes, and seconds

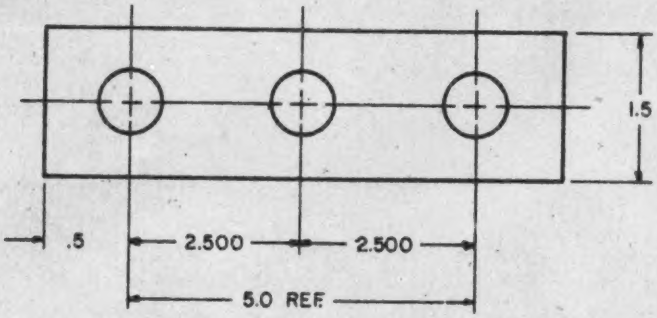
   Examples:



   (NOTE: The angle is the same, just referenced differently.)

4. Reference dimensions--Used for checking purposes; are without tolerances and not to be used for layout, machining or inspection

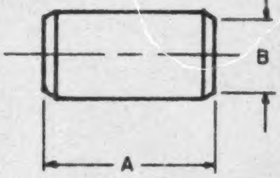
   Example:



5. Tabular dimensions--Used when a series of parts is made that has the same shape, but different sizes; dimensions are replaced with letters

   Example:

PART NO.	A	B
525	1.500	.500
526	1.250	.750
527	1.500	.875

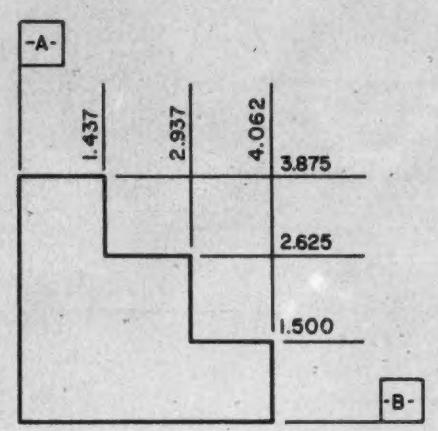


INFORMATION SHEET

6. Arrowless dimensioning--Used on drawings which contain datum lines

   (NOTE: All dimensions are from datum lines.)

   Example:

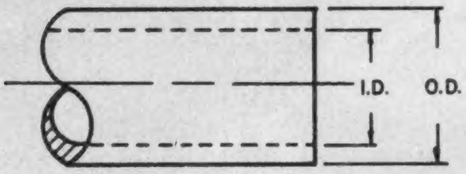


(NOTE: Another name for arrowless dimensioning is zero plane dimensioning.)

B. Tolerance

1. Nominal size--Used to designate size for a commercial product; may or may not be the true size

   Example: 3/4" steel pipe has an outside diameter of 1.05 and an inside diameter of .82

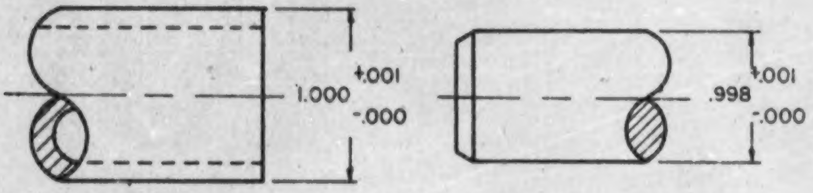


2. Basic size--The size of a part before allowances and tolerances are applied

INFORMATION SHEET

3. Allowance--The intentional difference in the dimensioning of mating parts; provides different classes of fits

   Example:

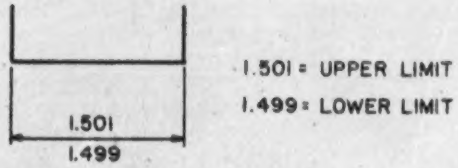

1.000
+.001
-.000
.998
+.001
-.000

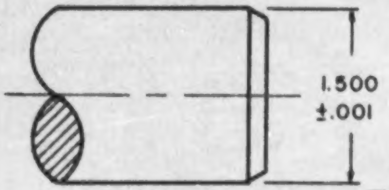
4. Actual size--Refers to the measured size of a part

5. Limits--The extreme permissible dimensions of a part resulting from use of tolerances

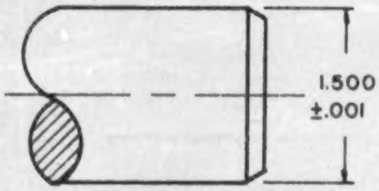
   (NOTE: If there is only one limit given, the other is assumed to be zero [O].)

   Examples:


1.501 = UPPER LIMIT
1.499 = LOWER LIMIT
1.501
1.499



BILATERAL TOLERANCE



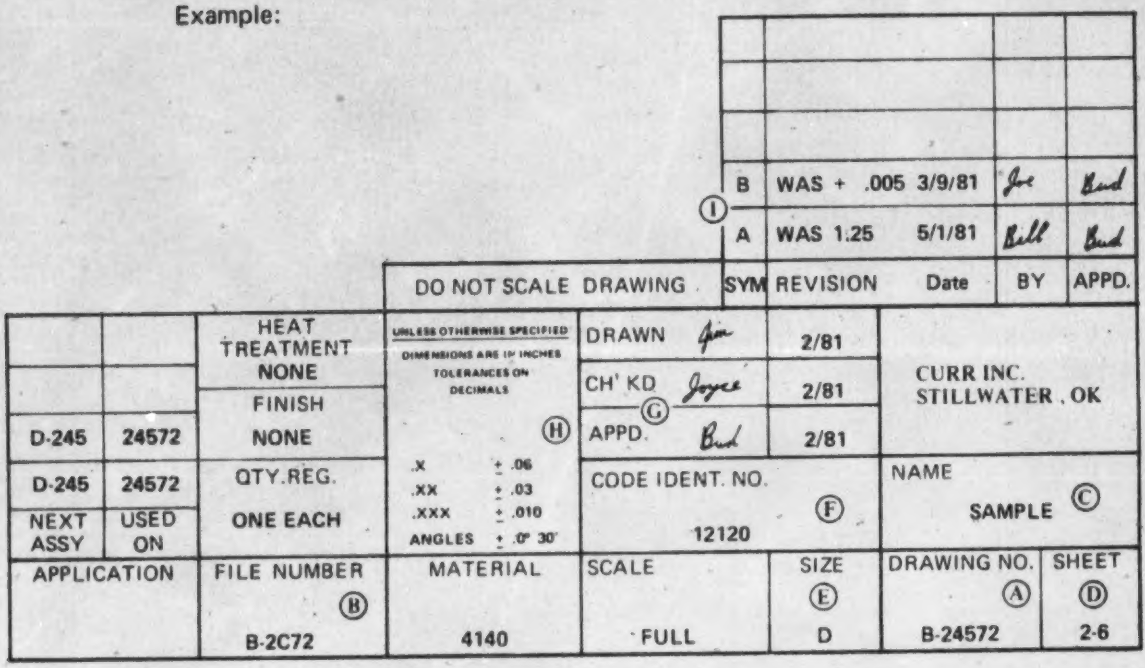
UNILATERAL TOLERANCE

INFORMATION SHEET

IX. Types of information found in blueprint title block (Assignment Sheet #6)

(NOTE: The information found in a title block may vary depending on the company or draftsperson. The title block is usually located in the lower right-hand corner of the blueprint.)

Example:



SYM	REVISION	Date	BY	APPD.
B	WAS + .005	3/9/81	Joe	Bud
A	WAS 1.25	5/1/81	Bill	Bud

Ⓘ

DO NOT SCALE DRAWING

		HEAT TREATMENT NONE	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON DECIMALS Ⓗ
		FINISH	.X ± .06
D-245	24572	NONE	.XX ± .03
D-245	24572	QTY.REG.	.XXX ± .010
NEXT ASSY	USED ON	ONE EACH	ANGLES ± .0° 30'
APPLICATION		FILE NUMBER Ⓑ B-2C72	MATERIAL 4140

DRAWN	Jim	2/81
CH' KD Ⓖ	Joyce	2/81
APPD.	Bud	2/81
CODE IDENT. NO. Ⓕ 12120		

CURR INC.
STILLWATER , OK

NAME
SAMPLE Ⓒ

SCALE	SIZE Ⓔ	DRAWING NO. Ⓐ	SHEET Ⓓ
FULL	D	B-24572	2-6

A. Drawing number

B. File number

C. Name

D. Sheet

Example: 1-3 means that it is sheet one of three sheets

E. Scale

Examples: 1/2" = 1" (Part is drawn 1/2 actual size)

1:1 (Part is drawn actual size)

(NOTE: If a measurement is missing or you think one of the called-out dimensions is wrong, NEVER scale the drawing with a measuring tool. Report it to your instructor because lines cannot be drawn exactly to thousandths of an inch.)

INFORMATION SHEET

F. Code identification number

(NOTE: If the industry is doing work for the Federal Government, it is assigned a special number that will appear on the drawing.)

G. Signatures

1. Person who approves drawing for release
2. Person who drew blueprint
3. Person who checked drawing
4. Person who designed part

H. Tolerances

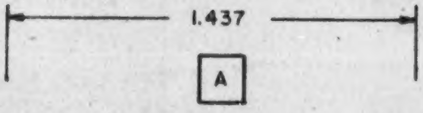
Example: 1.500 + .001

(NOTE: This block is needed when the general tolerances are given unless specified differently with the callout.)

I. Revisions

(NOTE: Revisions are noted to tell what was changed, who made the change, who approved the change, and when the change was made. Revision box is always located with the title block.)

Example:



NO.	REVISIONS	DATE	BY	APP.
A	WAS 1.5	2/2/80	J.D.	B.H.

INFORMATION SHEET

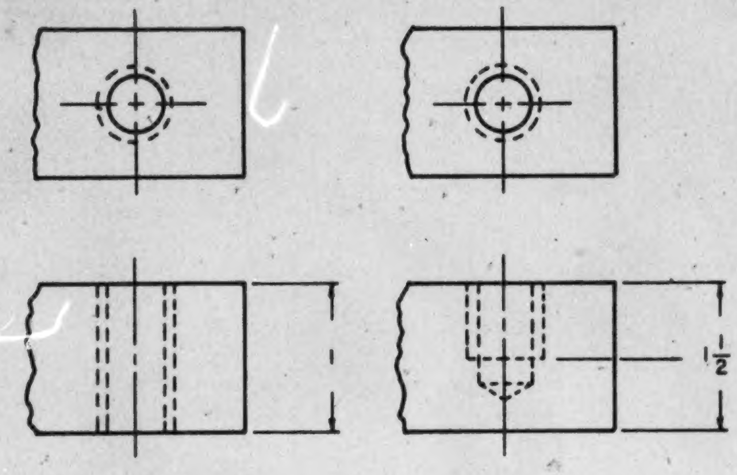
X. Machine specifications and processes (Assignment Sheets #8 and #9)

A. Representation--Used on blueprints to represent operations to be performed

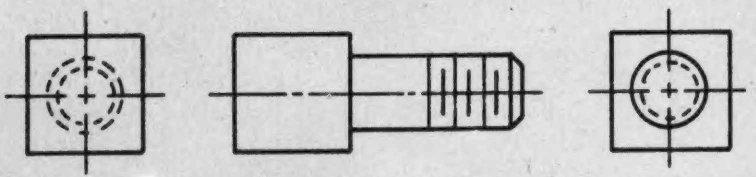
1. Thread representation

(NOTE: Threaded areas are designated for internal and external threads.)

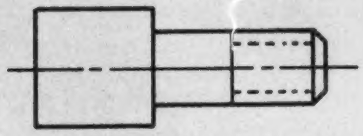
a. Internal



b. External



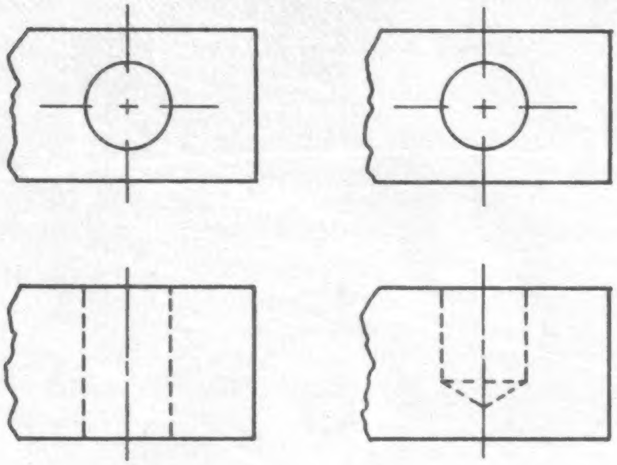
CONVENTIONAL REPRESENTATION



SIMPLIFIED REPRESENTATION

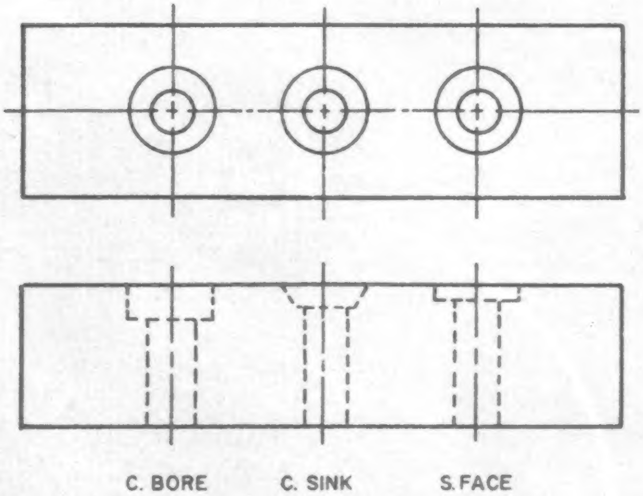
INFORMATION SHEET

2. Drilled or drilled and reamed



3. Counterbore, countersink, and spot face

   (NOTE: Counterbore, countersink and spot face are operations performed on a hole for different purposes.)

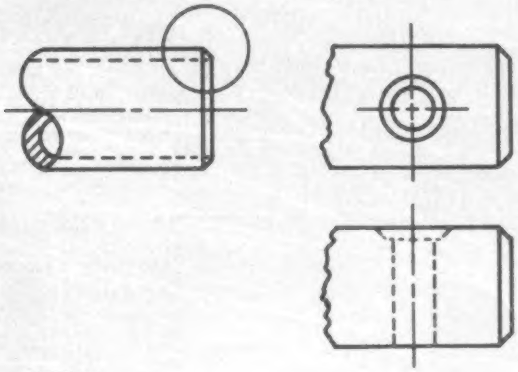


INFORMATION SHEET

4. Chamfer, fillet, round, and boss

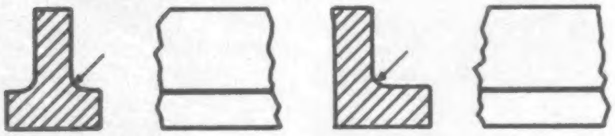
a. Chamfer

(NOTE: Chamfer removes sharp edges.)



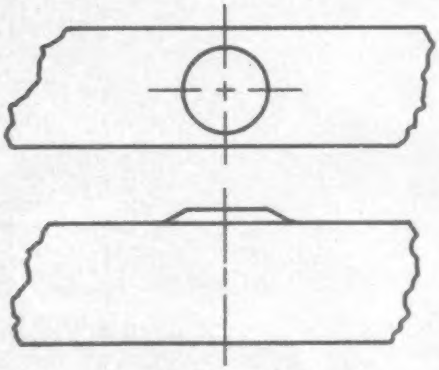
b. Fillet

(NOTE: Fillet provides strength to a part.)



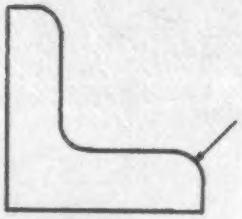
c. Boss

(NOTE: A boss is a circular projection on a casting.)



INFORMATION SHEET

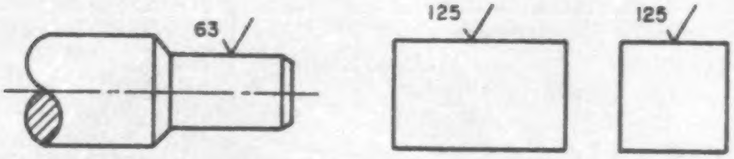
d. Round



5. Finish (surface texture)

(NOTE: Finish refers to the roughness, waviness, lay and flow of the surface, represented with a symbol and a number [63√].)

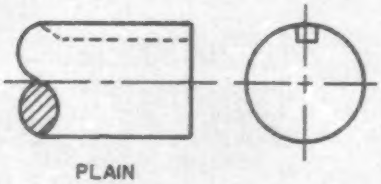
(NOTE: Finish will be covered in depth in Gaging and Inspection Tools unit.)



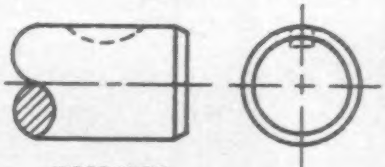
6. Keyway

(NOTE: A keyway is a surface cut to use a key to secure and align one part to another.)

a. External keyway



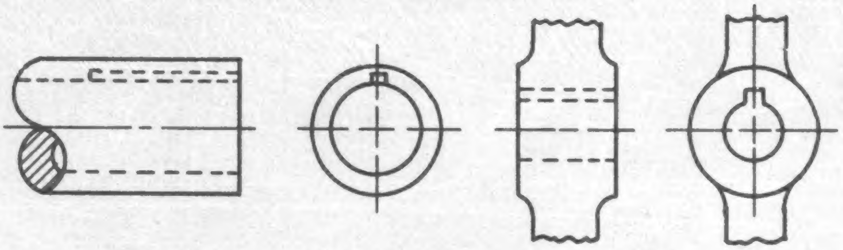
PLAIN



WOODRUFF

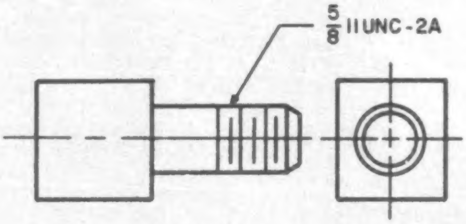
INFORMATION SHEET

b. Internal keyway



B. Callout--Used on blueprints where a certain specification or procedure is to be followed

1. External thread


$\frac{5}{8}$ 11UNC-2A

5/8" - DIA. BOLT

11-THREADS TO THE INCH

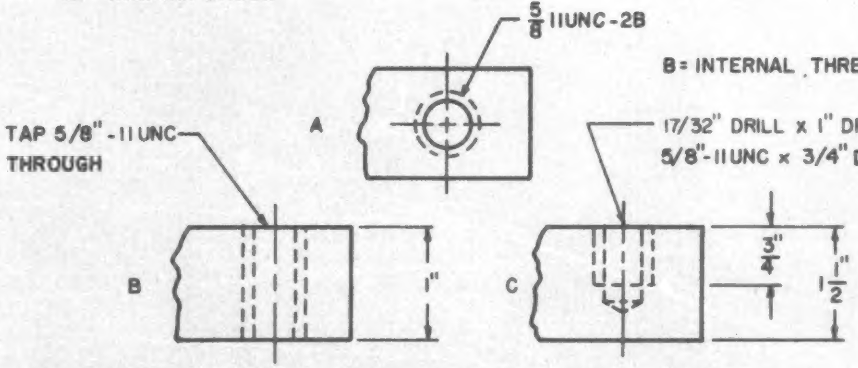
UN-UNIFIED NATIONAL FORM

C-COARSE SERIES

2-CLASS OF FIT

A-EXTERNAL THREADS

2. Internal thread

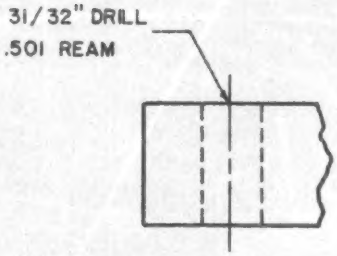

$\frac{5}{8}$ 11UNC-2B
TAP 5/8"-11UNC
THROUGH
A
B
1"
C
17/32" DRILL x 1" DP
5/8"-11UNC x 3/4" DP
$\frac{3}{4}$"
$1\frac{1}{2}$"

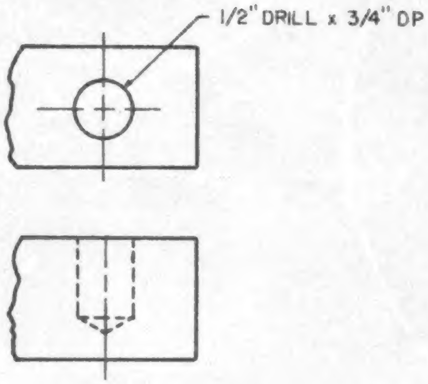
B= INTERNAL THREADS

(NOTE: All three places designate a 5/8" 11UNC tapped hole; however, C tells you to drill 17/32 diameter 1 inch deep and tap 3/4" deep. A represents the top view for B or C.)

INFORMATION SHEET

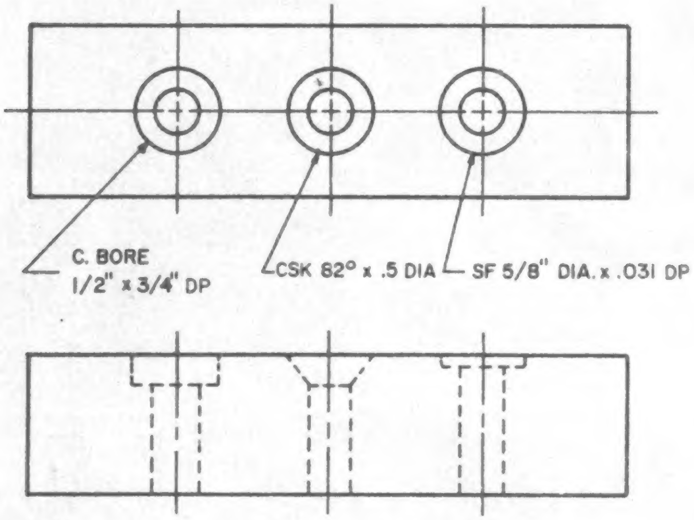
3. Drilled or reamed hole


31/32" DRILL
.501 REAM


1/2" DRILL x 3/4" DP

(NOTE: In some cases holes are specified drilled, or drilled to a particular size and then reamed; other times holes are to be drilled to a specified diameter and depth.)

4. Counterbore, countersink, and spot face

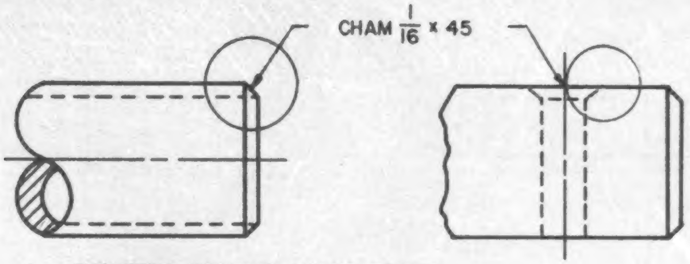

C. BORE
1/2" x 3/4" DP
CSK 82° x .5 DIA
SF 5/8" DIA. x .031 DP

(NOTE: Top views all look the same, but are called out differently.)

INFORMATION SHEET

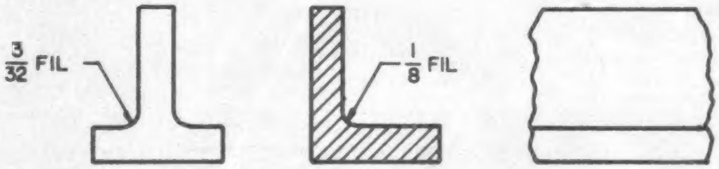
5. Chamfer, fillet, and boss

   a. Chamfer


CHAM $\frac{1}{16}$ × 45

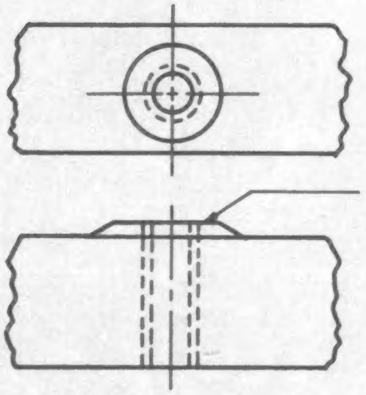
CHAMFERS REMOVE SHARP EDGES

   b. Fillet


$\frac{3}{32}$ FIL
$\frac{1}{8}$ FIL

FILLETS PROVIDE STRENGTH TO PART

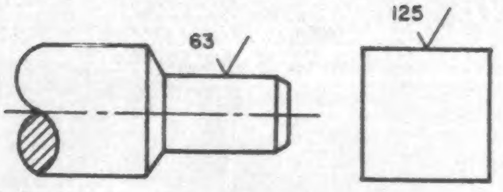
   c. Boss



THIS SURFACE IS 3/32" HIGH AND APX. 3/4" DIA. USUALLY FOUND ON CAST PARTS.

INFORMATION SHEET

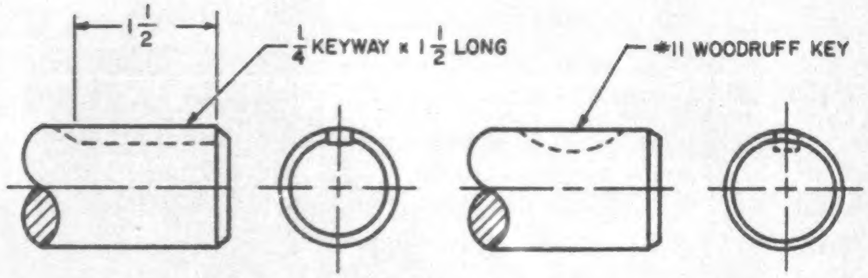
6. Finish



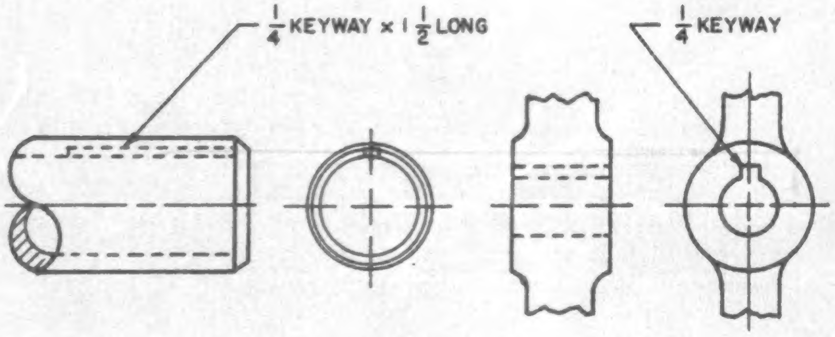
FINISH REFERS TO THE SMOOTHNESS OF A SURFACE. THE LARGER THE NUMBER, THE COARSER THE GRAIN.

7. Keyways

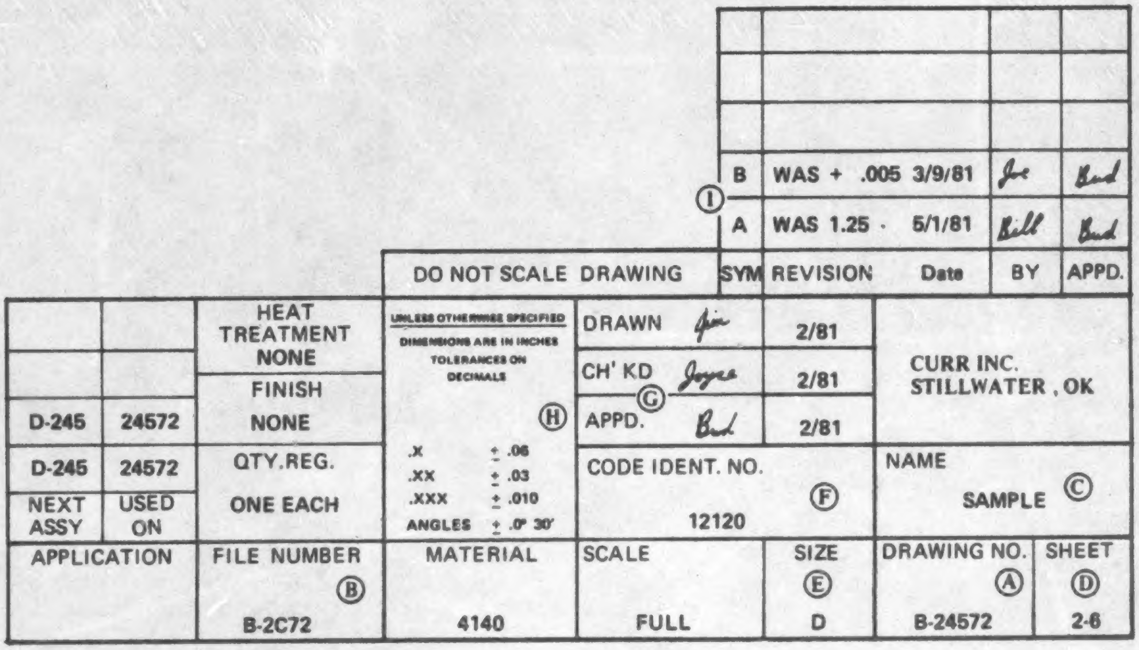
a. External keyway


$1\frac{1}{2}$
$\frac{1}{4}$ KEYWAY × $1\frac{1}{2}$ LONG
#11 WOODRUFF KEY

b. Internal keyway


$\frac{1}{4}$ KEYWAY × $1\frac{1}{2}$ LONG
$\frac{1}{4}$ KEYWAY

Title Block


B
WAS + .005 3/9/81
Joe
Bud
Ⓘ
A
WAS 1.25 · 5/1/81
Bill
Bud
DO NOT SCALE DRAWING
SYM
REVISION
Date
BY
APPD.
HEAT TREATMENT NONE
FINISH
NONE
D-245
24572
D-245
24572
QTY. REQ.
ONE EACH
NEXT ASSY
USED ON
APPLICATION
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON DECIMALS
Ⓗ
.X ± .06
.XX ± .03
.XXX ± .010
ANGLES ± 0° 30'
DRAWN
Jim
2/81
CH' KD
Joyce
Ⓖ
2/81
APPD.
Bud
2/81
CURR INC.
STILLWATER, OK
CODE IDENT. NO.
Ⓕ
12120
NAME
SAMPLE
Ⓒ
FILE NUMBER
Ⓑ
B-2C72
MATERIAL
4140
SCALE
FULL
SIZE
Ⓔ
D
DRAWING NO.
Ⓐ
B-24572
SHEET
Ⓓ
2-6

A. Drawing Number
B. File Number
C. Name
D. Sheet
E. Scale
F. Code Identification Number
G. Signatures
H. Tolerances
I. Revisions

BLUEPRINTS
UNIT II

ASSIGNMENT SHEET #1–MATCH BLUEPRINT SYMBOLS TO THEIR DEFINITIONS

NAME ______________________________ SCORE ______________

Symbols are used to represent words or phrases to keep from cluttering up the blueprint. It is important that you know the meaning of these symbols so you can interpret blueprints.

Match the symbols shown below to their correct meanings. Write the correct numbers in the blanks provided.

1. ⌖
2. ◎
3. ⌯
4. ⏥
5. —
6. ℄
7. ∠
8. ○
9. ↗
10. ⌭
11. //
12. ⊥

_____ a. Perpendicularity

_____ b. Parallelism

_____ c. Roundness

_____ d. Angularity

_____ e. Straightness

_____ f. Runout

_____ g. Cylindricity

_____ h. Flatness

_____ i. Symmetry

_____ j. True position

_____ k. Concentricity

_____ l. Center line

BLUEPRINTS
UNIT II

ASSIGNMENT SHEET #2--WRITE MEANINGS OF ABBREVIATIONS USED ON BLUEPRINTS

NAME________________________________ SCORE ______________

Abbreviations, like symbols, are used to keep from cluttering up the blueprint with long words. If you are to read a blueprint you must know the meaning of these abbreviations.

Write the correct meaning for each abbreviation.

a. Par-- ____________________
b. SYM-- ____________________
c. No-- ____________________
d. NTP-- ____________________
e. TIR-- ____________________
f. Dia-- ____________________
g. F or Fin-- ____________________
h. USS-- ____________________
i. ID-- ____________________
j. SQ-- ____________________
k. CC-- ____________________
l. UNC-- ____________________
m. CI-- ____________________
n. FS-- ____________________
o. TYP-- ____________________
p. R or Rad-- ____________________
q. CRS-- ____________________
r. AISI-- ____________________

ASSIGNMENT SHEET #2

s. Req'd or Req-- ____________________

t. Csk-- ____________________

u. Hex-- ____________________

v. FAO-- ____________________

w. CB or C'Bore-- ____________________

x. SAE-- ____________________

y. PD-- ____________________

z. OD-- ____________________

BLUEPRINTS
UNIT II

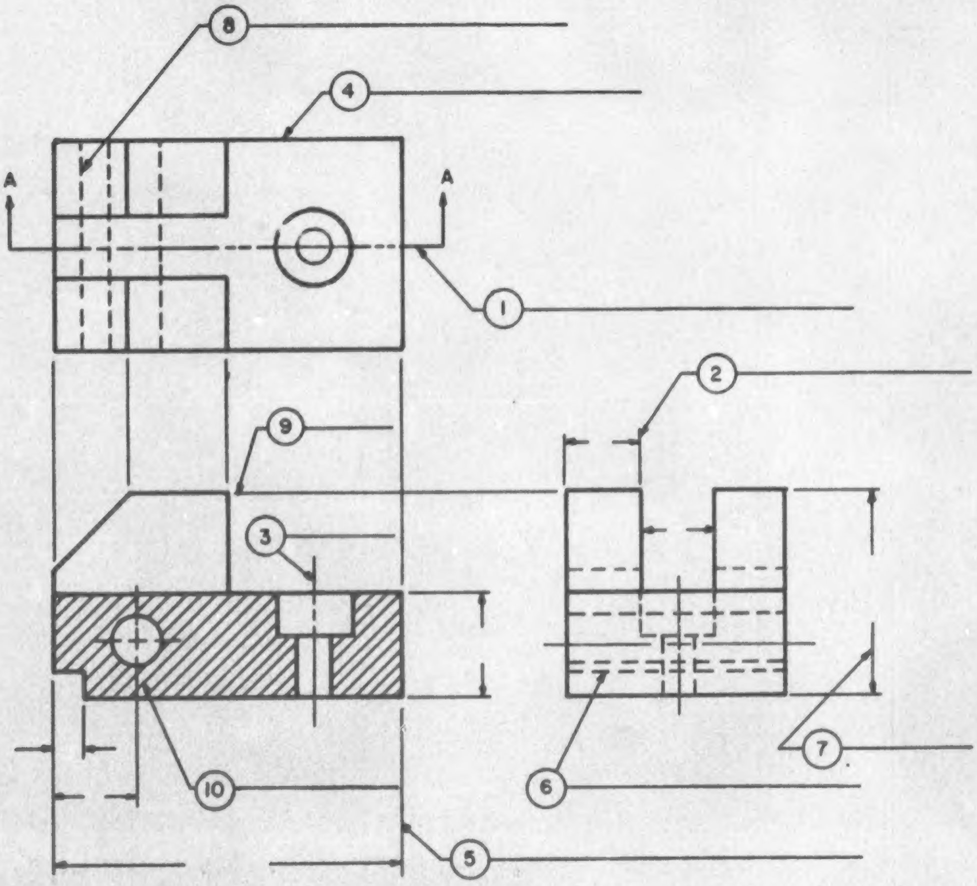
ASSIGNMENT SHEET #3--IDENTIFY LINES ON BLUEPRINTS

NAME ______________________________ SCORE ______________

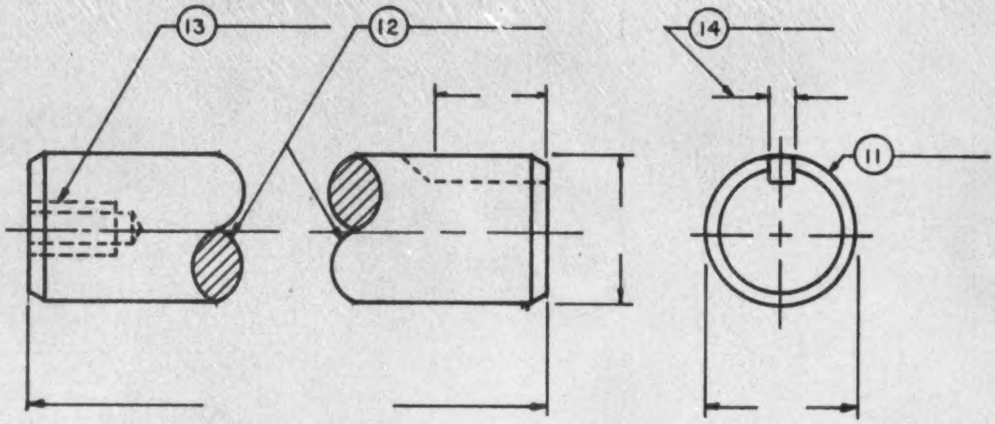
Knowledge of blueprint lines helps you interpret what you are looking at so that you can form a mental picture of the print.

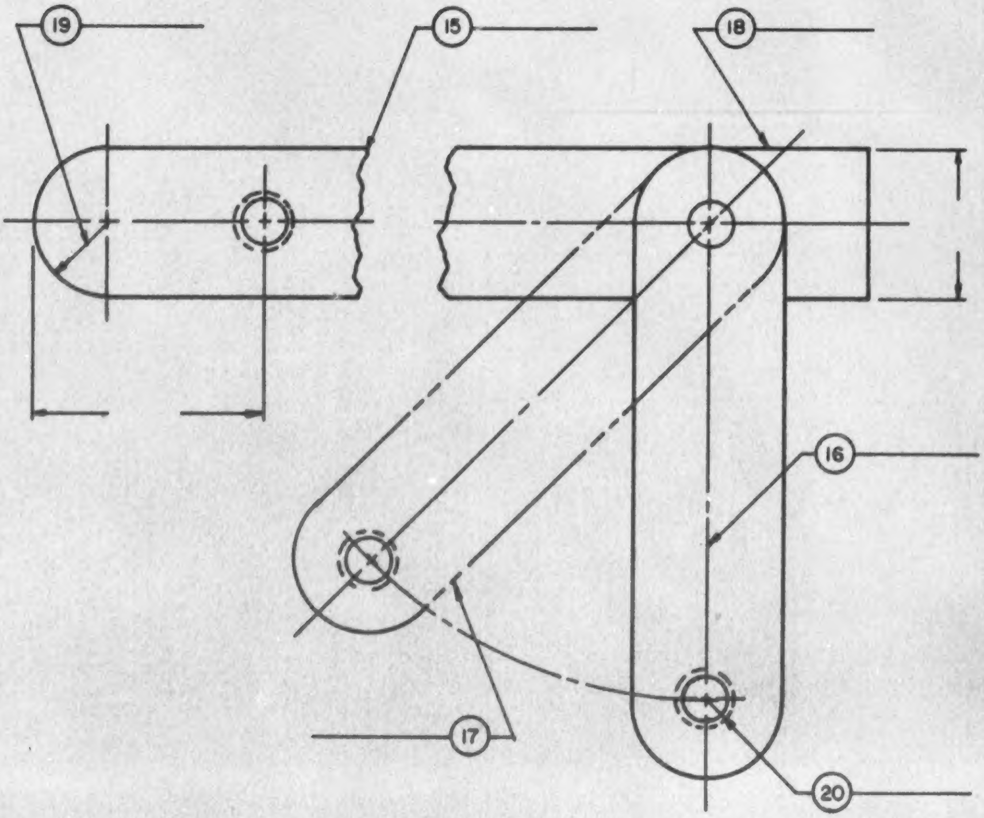
From the illustrations below and on the next page select the proper name of each line indicated from the list. Then write the correct name in the blanks provided. Some types of lines may be used more than once.

Object line
Hidden line
Section line
Center line
Dimension line
Extension lines
Cutting plane lines
Short break lines
Phantom lines
Projection lines



ASSIGNMENT SHEET #3




19
15
18
16
17
20

BLUEPRINTS
UNIT II

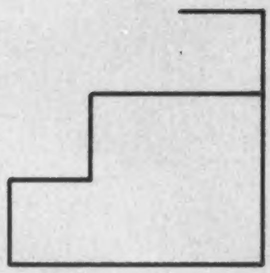
ASSIGNMENT SHEET #4--COMPLETE ORTHOGRAPHIC PROJECTION DRAWINGS

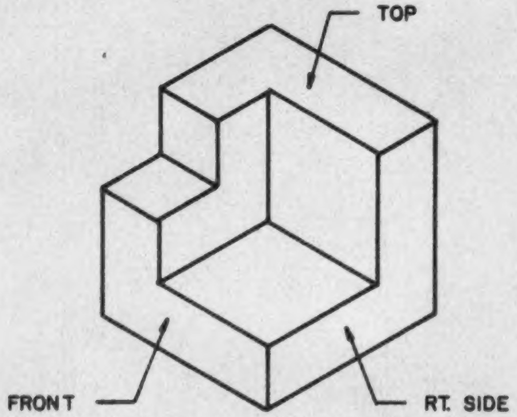
NAME____ SCORE __________________

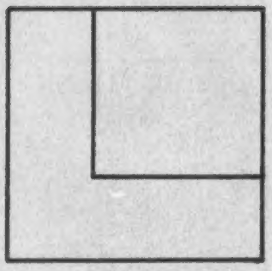
Understanding orthographic projection drawings helps you in forming a mental picture of the finished part. This will help in the machining process.

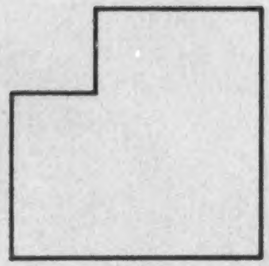
PART I

Complete the three views shown below by adding the missing lines.





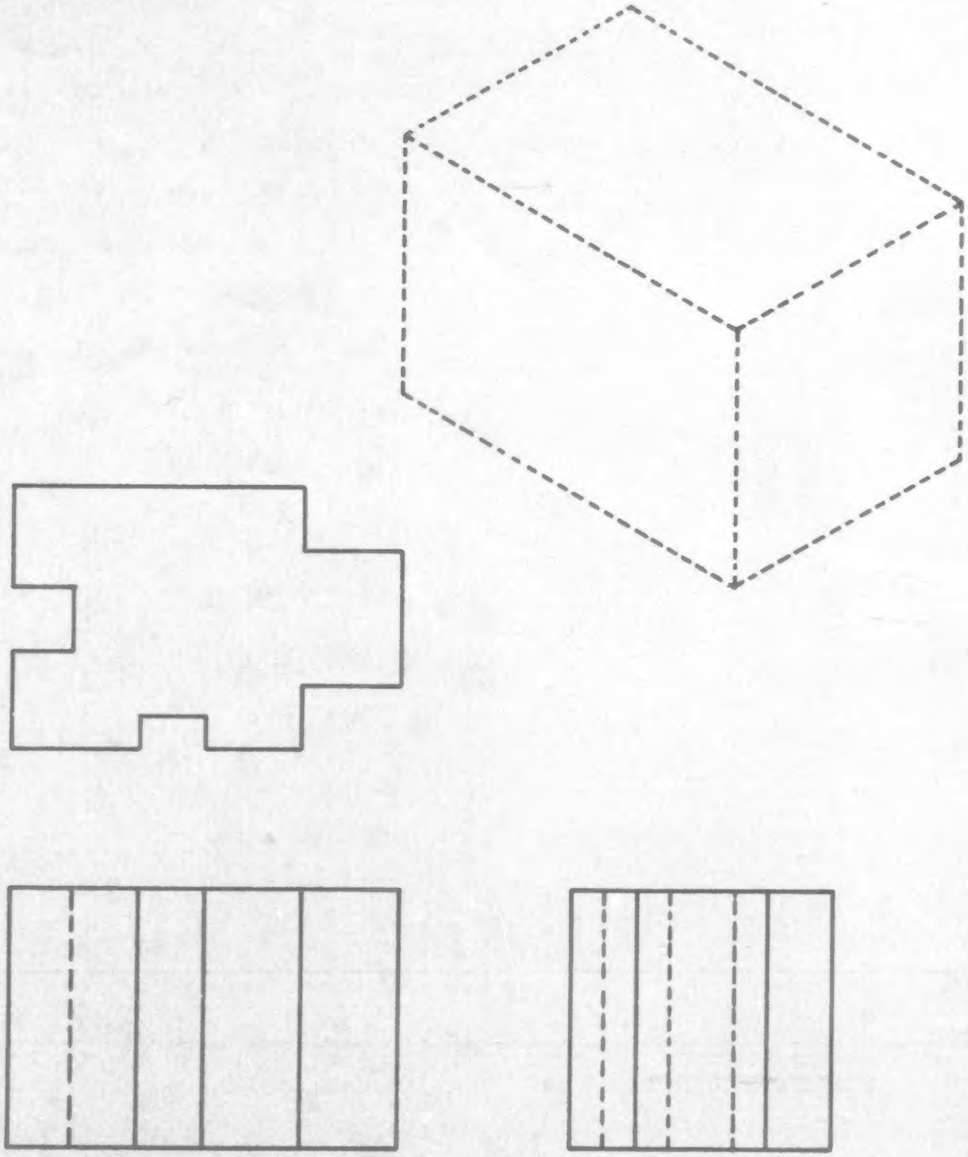




ASSIGNMENT SHEET #4

PART II

From the three views shown, complete the isometric view.



BLUEPRINTS
UNIT II

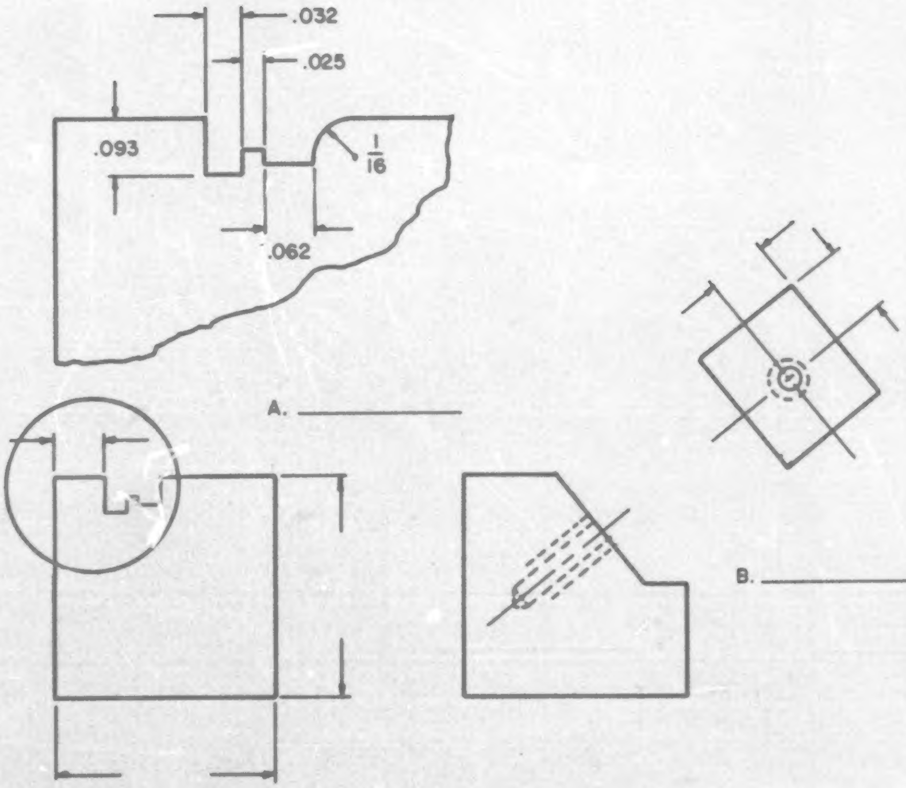
ASSIGNMENT SHEET #5--IDENTIFY OTHER VIEWS OF BLUEPRINTS

NAME____ SCORE __________________

Sometimes it is necessary to use special views of an object for clarity.

Identify the different views shown below and on the next page by matching the correct name of the view to the drawings.

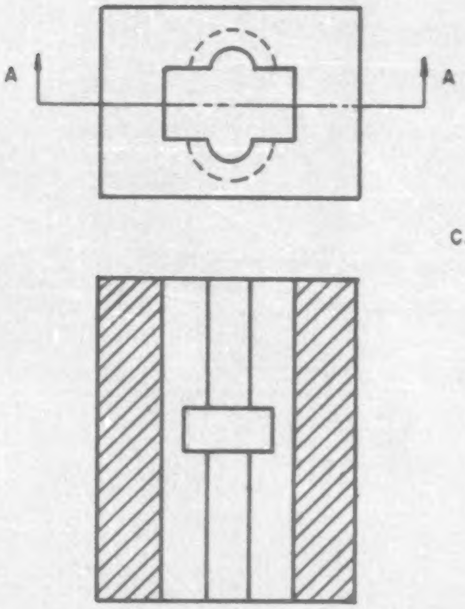
1. Isometric view
2. Detail view
3. Section view
4. Auxiliary view



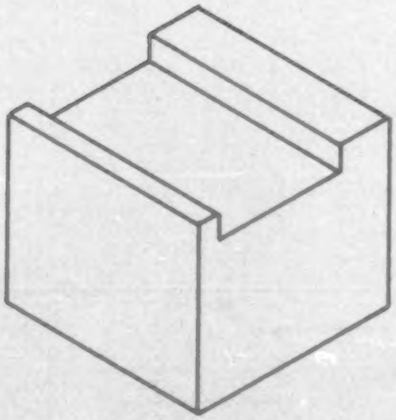
A. __________________

B. __________________

ASSIGNMENT SHEET #5



C. ____________________



D. ____________________

BLUEPRINTS
UNIT II

ASSIGNMENT SHEET #6--LOCATE INFORMATION ON THE TITLE BLOCK

NAME________________________________ SCORE ______________

The title block has important information that is necessary to make the part.

Answer the following questions concerning the title block illustrated.

REVISIONS	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON DECIMALS .XX ± .005 .XXX ± .0015 ANGLES ± 30"		PROJ ENGER	Bill D.	J. J. DESIGN INC.	
			DRAWN BY	J.D.	JACK SHAFT	
			CHECKER	Jack		
			APP BY	Sam S.	CODE 15261	022536
	MATERIALS 4140	FINISH BLK OXIDE	DATE	11/1/80	SCALE 1"/2"	SHEET

a. Who checked the drawing?____________________________

b. What is the scale of the drawing?____________________________

c. How many sheets are there in the drawing assembly?____________________

d. What kind of material is to be used?____________________________

e. Who is the project engineer?____________________________

f. What is the part name and number?____________________________

g. What is the Department of Defense number?________________________

h. What is the tolerance for a three-place decimal?________________________

i. Who is the draftperson?____________________________

j. What kind of finish is to be given to the part?________________________

k. What is the date of the drawing?____________________________

l. Have there been any changes made?____________________________

m. Who approved the blueprint?____________________________

BLUEPRINTS
UNIT II

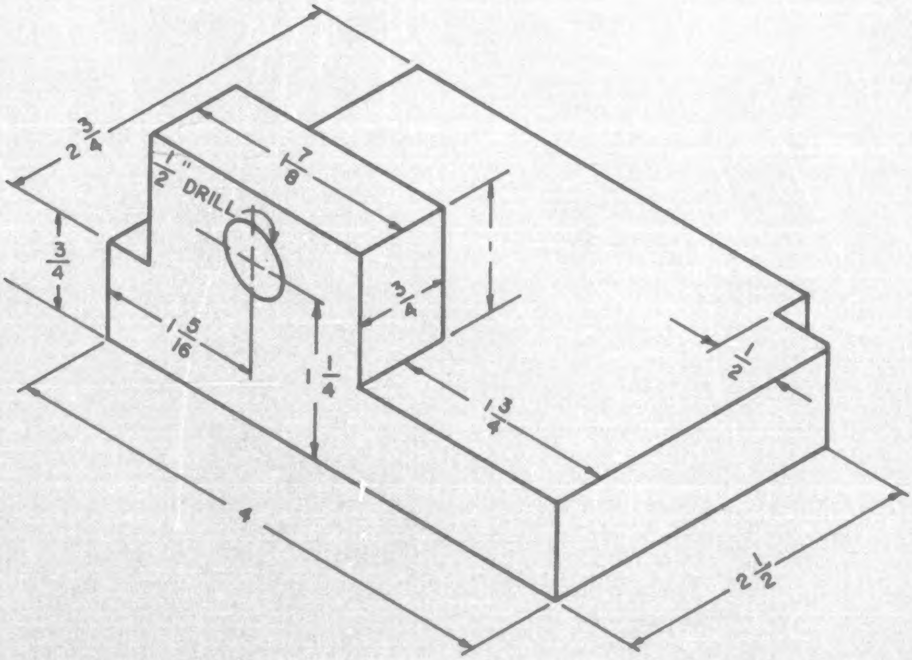
ASSIGNMENT SHEET #7--SKETCH ORTHOGRAPHIC PROJECTIONS

NAME__________________________________ SCORE _______________

Visualizing what a part looks like on paper is helpful in the interpretation of blueprints.

PART I

Sketch a three-view drawing of the part illustrated below. Put in all lines that would be required to make the part. Use the graph paper provided and make the sketch proportional.



ASSIGNMENT SHEET #7

NAME__________________________________ SCORE _______________

(NOTE: Each square equals 1/8 inch.)

ASSIGNMENT SHEET #7

PART II

Sketch a three-view drawing of a 1/2" plate of aluminum 3 1/2" wide and 4 3/4" long. Cut a 3/8" slot down its length and centered on the width 1/8" deep. Drill 4 3/8" holes in each corner 3/4" from edges and counterbore 5/8" dia. x 1/4" deep from side opposite slot. Use the graph paper provided.

ASSIGNMENT SHEET #7

NAME________________________________ SCORE ________________

(NOTE: Each square equals 1/8 inch.)

BLUEPRINTS
UNIT II

ASSIGNMENT SHEET #8--IDENTIFY MACHINING SPECIFICATIONS AND PROCESSES

NAME______________________________ SCORE ______________

It is common practice to use abbreviations and symbols on drawings that if written out or drawn completely would require too much time. Many of these have become universal, so for you to know what is to take place you must know these symbols and abbreviations.

From the illustrations on the next page, select the proper meaning from the list provided and write the letter in the space provided.

a. External schematic thread representation

b. Unified National Coarse

c. Class of a bolt

d. Internal threaded hole

e. Diameter and depth of drilled hole

f. Counterbore a hole

g. Ream a hole

h. A chamfered hole

i. A countersunk hole

j. A spot faced hole

k. Represents concentricity

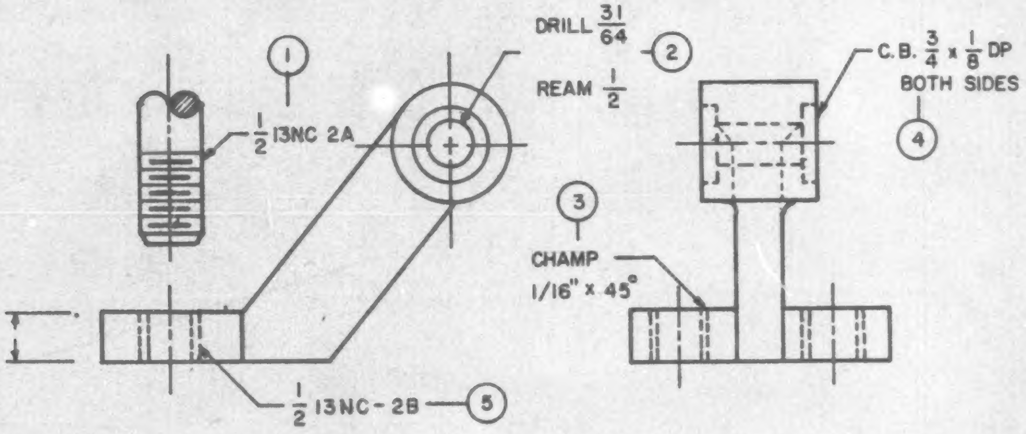
l. Represents finish

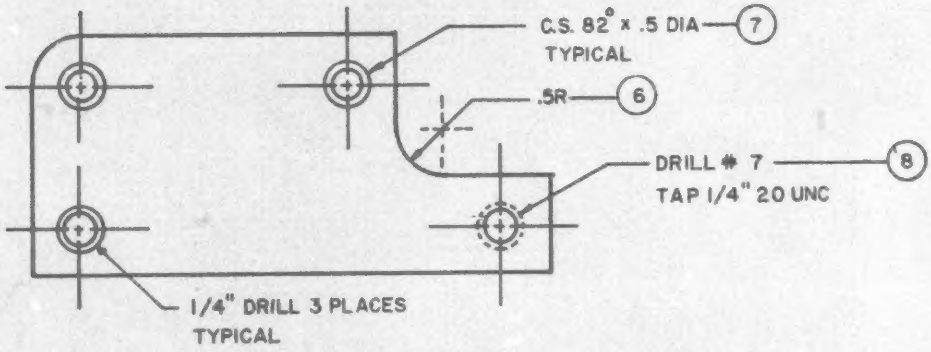
m. A drilled and tapped hole

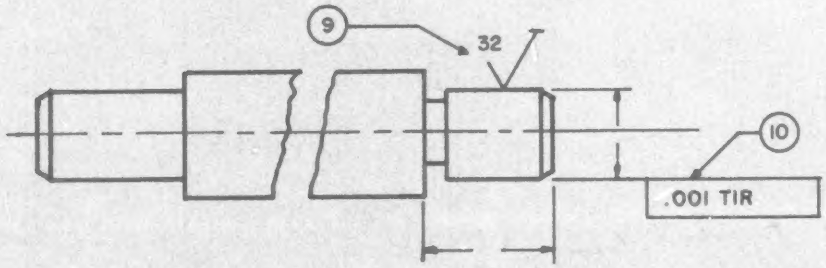
n. Size of a particular bolt

o. Represents a radius

ASSIGNMENT SHEET #8


①
1/2 13NC 2A
DRILL 31/64
REAM 1/2
②
C.B. 3/4 x 1/8 DP
BOTH SIDES
④
③
CHAMP
1/16" x 45°
1/2 13NC - 2B
⑤


C.S. 82° x .5 DIA
TYPICAL
⑦
.5R
⑥
DRILL # 7
TAP 1/4" 20 UNC
⑧
1/4" DRILL 3 PLACES
TYPICAL


⑨
32
⑩
.001 TIR

_____1.

_____2.

_____3.

_____4.

_____5.

_____6.

_____7.

_____8.

_____9.

_____10.

BLUEPRINTS
UNIT II

ASSIGNMENT SHEET #9--READ BLUEPRINTS

NAME________________________________ SCORE ______________

Having a good understanding of what is to be made, and to what degree of accuracy, is as important as knowing how to operate the equipment. Read the blueprint on the next page and answer the questions below.

a. What type of line is (1)?______________________________

b. What line in the front view represents surface (6)?______________________________

c. The lines (2 and 3) are represented by what line in the side view?______________

d. What kind of material is to be used to make the part?______________________

e. What is the dimension of (4)?______________________________

f. What does ◎ B.005 imply? ______________________________

g. What does the line A-A indicate?______________________________

h. What is the thickness of the flange?______________________________

i. What is the tolerance of the bolt hole circle?______________________________

j. What is the finish of the bore to be?______________________________

k. What does ⊥ A.002 imply? ______________________________

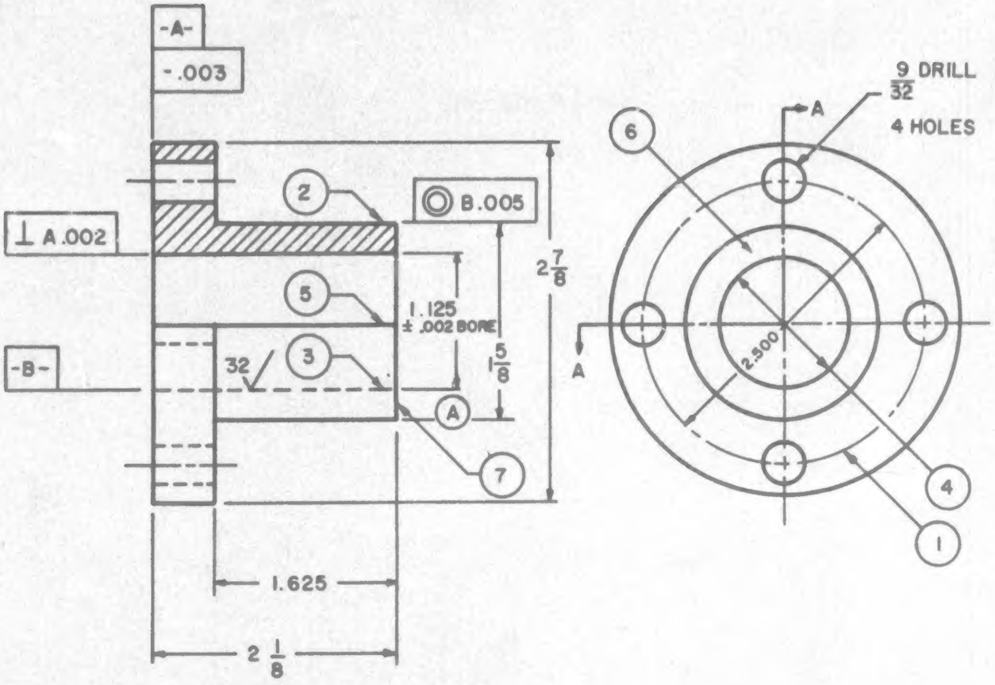
l. Have any changes been made?______________________________

m. Who approved the drawing?______________________________

n. What is the scale used to draw the sketch?______________________________

o. What do the slanted lines represent?______________________________

ASSIGNMENT SHEET #9


-A-
-.003
⊥ A.002
-B-
2
5
3
32
1.125
± .002 BORE
◎ B.005
2 7/8
1 5/8
A
7
1.625
2 1/8
9/32 DRILL
4 HOLES
A
A
6
2.500
4
1

Ⓐ	1.124±.001	11/22/80	REV	QTY.	ORDER#	DATE	DWG. BY	CK. BY	APP.BY
NO.	CHANGE	DATE	BY	6	26 - 622	7/6/40	SCALE 1=1	MAT. C.I.	H.T. NONE

UNLESS OTHERWISE SPECIFIED:
LIMITS ON DECIMAL DIMENSIONS WITHIN ±.005"
LIMITS ON FRACTIONAL DIMENSIONS WITHIN ±1/64"
LIMITS ON ANGULAR DIMENSIONS WITHIN ±1/2°

FLANGED BUSHING

FINISH

FINISH ALL OVER
BREAK ALL SHARP EDGES

D-8

BLUEPRINTS
UNIT II

ASSIGNMENT SHEET #10--READ AN INDUSTRIAL BLUEPRINT

NAME________________________________ SCORE ______________

Regardless of how well you can operate the equipment, if you are not capable of understanding information obtained from the blueprint, your part will not be right the first time. Read the blueprint on the next page and answer the questions below.

a. How many datum surfaces are indicated?______________________

b. What is the maximum allowable tolerance on the diameter of the bore?__________

c. What is the diameter of the bolt hole circle?______________________

d. How many threads to the inch are to be cut or chased on the flange?__________

e. How many degrees are there from one arc hole to the next hole?__________

f. What does $\boxed{// \text{A} .0025}$ mean?______________________

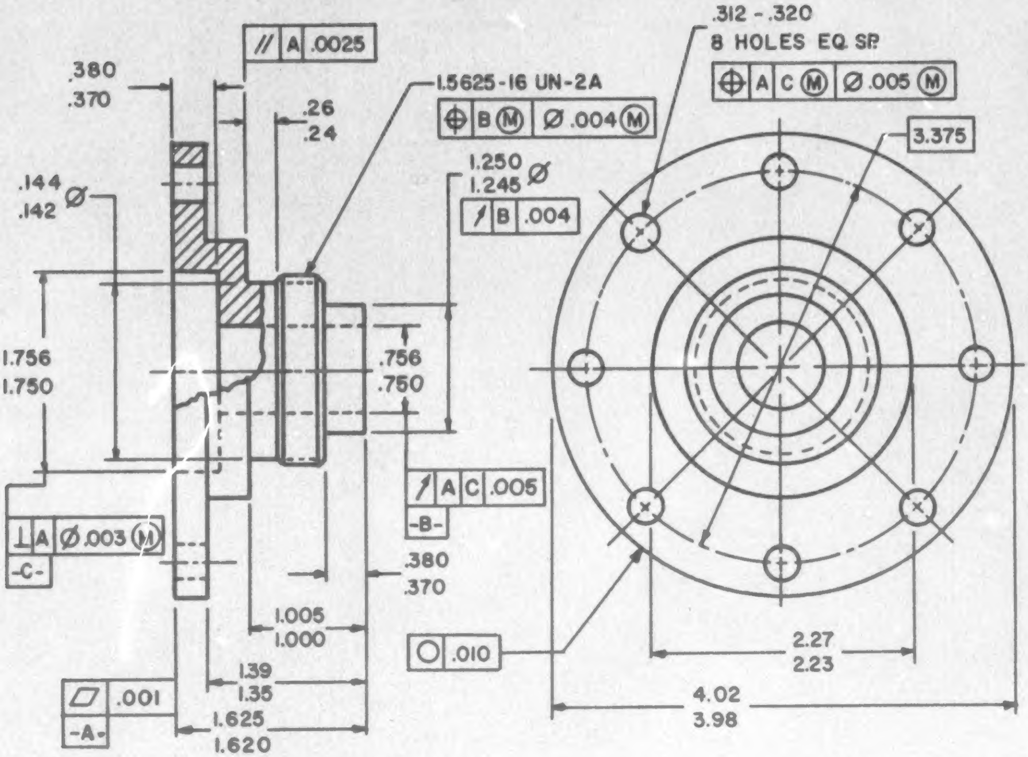
g. What does the symbol ∅ represent?______________________

h. What limits are there on the .312 holes?______________________

i. What is the maximum runout allowed from datum $\boxed{\text{-A- and -C-}}$?__________

j. What is the length of the part from datum $\boxed{\text{-A-}}$? ______________________

ASSIGNMENT SHEET #10


// | A | .0025
.380
.370
.26
.24
1.5625-16 UN-2A
⌖ | B Ⓜ | Ø .004 Ⓜ
1.250
1.245 Ø
↗ | B | .004
.144
.142 Ø
1.756
1.750
.756
.750
↗ | A | C | .005
-B-
⊥ | A | Ø .003 Ⓜ
-C-
.380
.370
1.005
1.000
1.39
1.35
▱ | .001
-A-
1.625
1.620
.312 - .320
8 HOLES EQ. SP.
⌖ | A | C Ⓜ | Ø .005 Ⓜ
3.375
○ | .010
2.27
2.23
4.02
3.98

(NOTE: Notice how much space is saved and how much neater the drawing is by using symbolic callouts rather than notes or long written descriptions of the requirements.)

BLUEPRINTS
UNIT II

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

a. 12
b. 11
c. 8
d. 7
e. 5
f. 9
g. 10
h. 4
i. 3
j. 1
k. 2
l. 6

Assignment Sheet #2

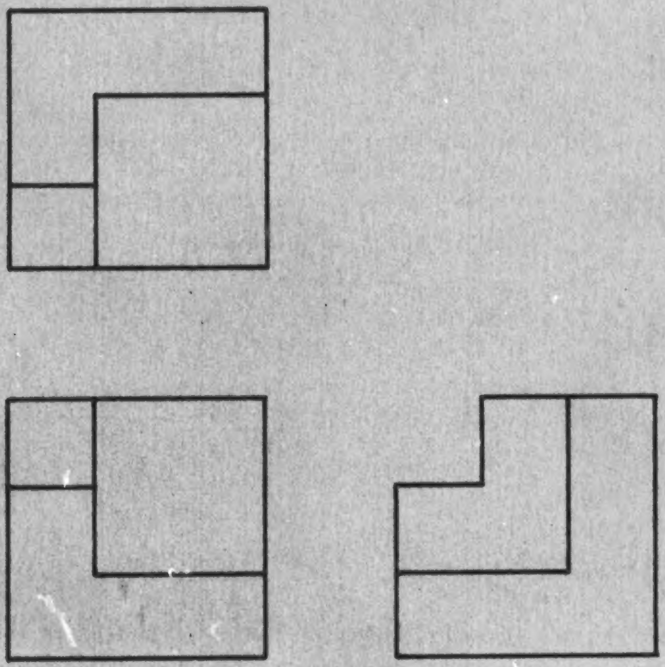
a. Parallel
b. Symmetrical
c. Number
d. American Standard Taper Pipe
e. Total indicator reading
f. Diameter
g. Finish
h. United States Standard
i. Inside diameter
j. Square
k. Center to center
l. Unified National Coarse
m. Cast iron
n. Full size
o. Typical
p. Radius
q. Cold rolled steel
r. American Iron and Steel Institute
s. Required
t. Countersink
u. Hexagon
v. Finish all over
w. Counterbore
x. Society of Automotive Engineers
y. Pitch diameter
z. Outside diameter

Assignment Sheet #3

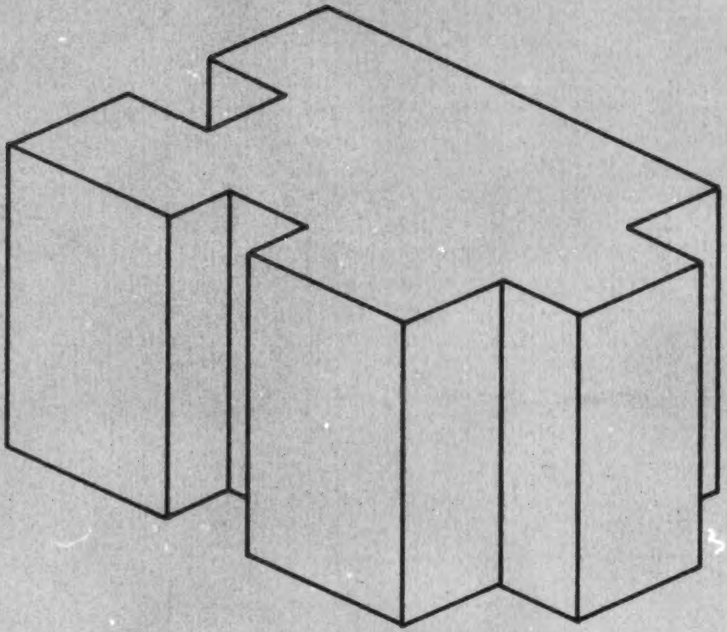
1. Cutting plane lines
2. Extension lines
3. Center line
4. Object line
5. Extension lines
6. Hidden line
7. Dimension line
8. Hidden line
9. Projection lines
10. Section line
11. Object line
12. Short break lines
13. Hidden line
14. Dimension line
15. Short break lines
16. Center line
17. Phantom lines
18. Object line
19. Dimension line
20. Hidden line

Assignment Sheet #4

PART I



PART II



Assignment Sheet #5

a. 2

b. 4

c. 3

d. 1

Assignment Sheet #6

a. Jack

b. 1" = 2"

c. 7

d. 4140

e. Bill D.

f. Jack Shaft 022536

g. 15261

h. +.0015

i. J.D.

j. Black oxide

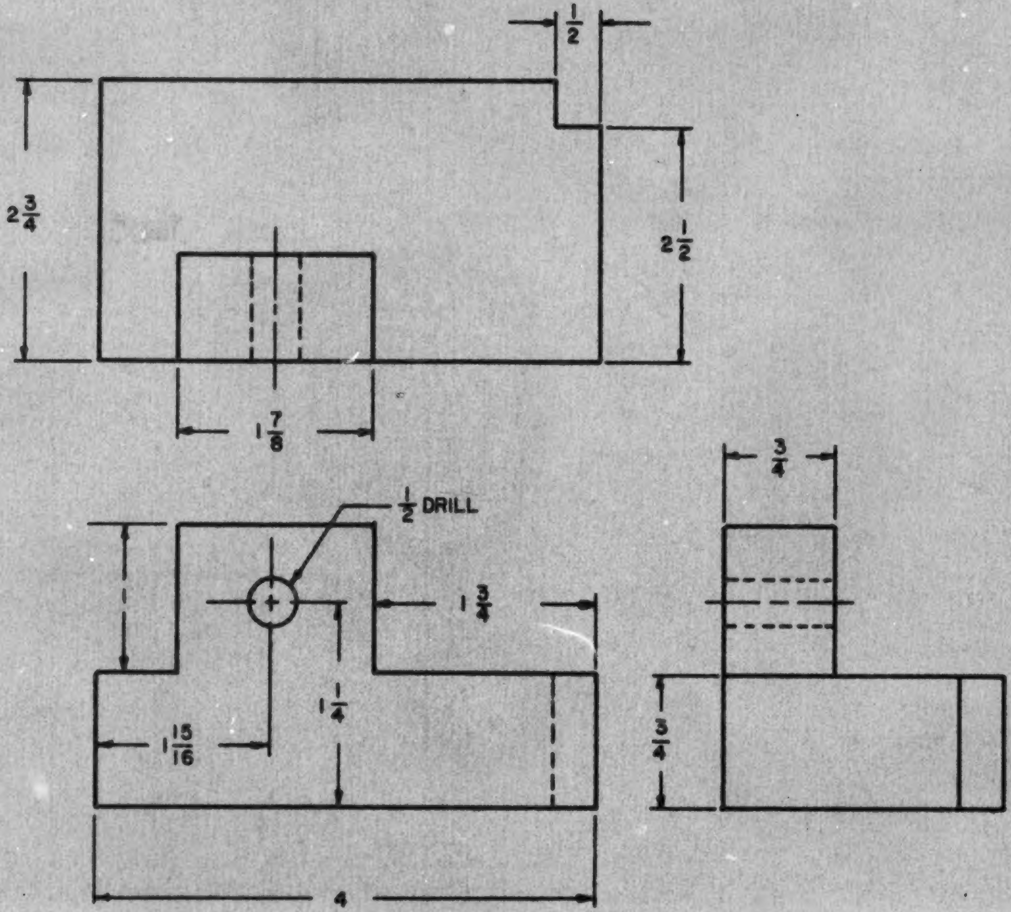
k. 11/1/80

l. No

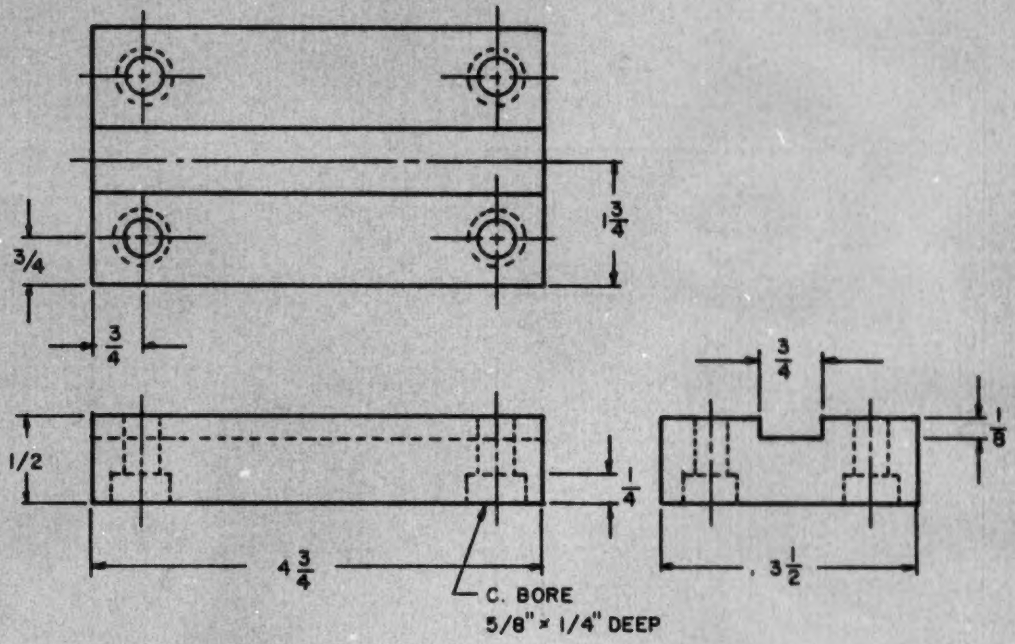
m. Sam S.

Assignment Sheet #7

PART I


1/2
2 3/4
2 1/2
1 7/8
1/2 DRILL
1 3/4
3/4
1 1/4
1 15/16
3/4
4

PART II


3/4
1 3/4
3/4
3/4
1/2
1/4
4 3/4
1/8
3 1/2
C. BORE
5/8" × 1/4" DEEP

Assignment Sheet #8

1. o
2. g
3. i
4. f
5. d
6. p
7. j
8. n
9. m
10. l

Assignment Sheet #9

a. Center line

b. 7

c. 4

d. Cast iron

e. 1.125 (+.002, -.000)

f. The 1 5/8" diameter is concentric to the base within .005

g. Section line

h. 1/2 inch

i. +.005

j. 32√

k. The bore is perpendicular to surface $\boxed{\text{-A-}}$ within .002

l. Yes

m. Bud

n. 1" = 1" or full

o. Section removed

Assignment Sheet #10

a. Three

b. .004

c. 3.375

d. 16

e. 45°

f. The shoulder behind the threads is to be parallel to A within .0025

g. Diameter

h. .312 to .320 or a total of .008 dfference

i. .005

j. 1.625 maximum

BLUEPRINTS
UNIT II

TEST

NAME______________________________ SCORE ______________

1. Match blueprint terms to their definitions. Write the correct numbers in the blanks provided. Terms and definitions continue on the next page.

______a. The process of making a flat surface perpendicular to a specific diameter and depth, usually less than .030 inch

______b. The process of heating a metal piece to a high temperature to soften it, and allowing it to cool slowly

______c. The process of cutting a relief in a diameter near a shoulder

______d. The process of hardening the outer surface of a steel part, forming a hard case on the metal while leaving the inner metal soft

______e. A series of small diamond-shaped or straight impressions pressed into a metal surface

______f. A circular projection on a casting

______g. Two or more surfaces that are the same distance apart at all points

______h. The process of finishing a drilled hole to an accurate size

______i. The process of lapping finished parts to very close tolerances, leaving the surface very smooth

______j. The process of enlarging a portion of a hole to a specific diameter and depth, usually greater than .030 inch

______k. A surface that is tapered at an angle other than a right angle to a reference surface

______l. A hole that is usually cut by using a boring tool; the surface is usually a locating surface

1. Anneal
2. Neck
3. Bevel
4. Bore
5. Boss
6. Spot face
7. Case harden
8. Knurl
9. Counterbore
10. Lap
11. Parallel
12. Ream

_____m. A projecting rim used for fastening or increasing strength

_____n. The process of finishing machined parts by means of a revolving abrasive wheel

_____o. A slot cut on a shaft or in the bore of a gear or pulley, into which is fitted a key

_____p. Circles lying in the same plane which partly coincide but do not have the same center

_____q. A curved inside corner formed to increase the strength of an object and improve its appearance

_____r. The process of tapering the top of a hole at a specific angle

_____s. The process of originating a hole by using a drill

_____t. Circles lying in the same plane with the same center

_____u. A support for a shaft or pivot

_____v. To remove a sharp external edge with a cutting tool, usually at an angle of 45° and a depth of .030 inch or less

_____w. Square or circular raised surface found on castings

_____x. An angular or rounded contour often found on the face of a pulley

_____y. Preparation process for tempering steel

13. Eccentric
14. Fillet
15. Flange
16. Grind
17. Keyway
18. Chamfer
19. Countersink
20. Bearing
21. Crown
22. Drill
23. Carburize
24. Concentric
25. Pad

2. Match symbols used on blueprints to the correct meanings. Write the correct numbers in the blanks provided.

a. ⌖ ______________________________

b. ◎ ______________________________

c. ⌯ ______________________________

d. ▱ ______________________________

e. — ______________________________

f. ○ ______________________________

g. ⌭ ______________________________

1. Flatness
2. Cylindricity
3. Straightness
4. True position
5. Symmetry
6. Roundness
7. Concentricity

h.	//	____________________	8. Perpendicularity
i.	⊥	____________________	9. Runout
j.	∠	____________________	10. Center line
k.	Ø	____________________	11. Parallelism
l.	↗	____________________	12. Diameter
m.	℄	____________________	13. Angularity
n.	√	____________________	14. Surface finish

3. Write the abbreviations used on blueprints for each of the following terms.

a. __________ Cast steel

b. __________ Square

c. __________ Hexagon

d. __________ Radius

e. __________ Inside diameter

f. __________ Full size

g. __________ Cold rolled steel

h. __________ Finish

i. __________ Countersink

j. __________ Cast iron

k. __________ Counterbore

l. __________ Center to center

m. __________ Finish all over

n. __________ On center

o. __________ Diameter

p. __________ Symmetrical

q. __________ Not to scale

r. __________ Society of Automotive Engineers

s. __________American Standard Taper Pipe

t. __________United States Standard

u. __________Total Indicator Reading

v. __________Parallel

w. __________Full Size Detail

x. __________Unified National Coarse

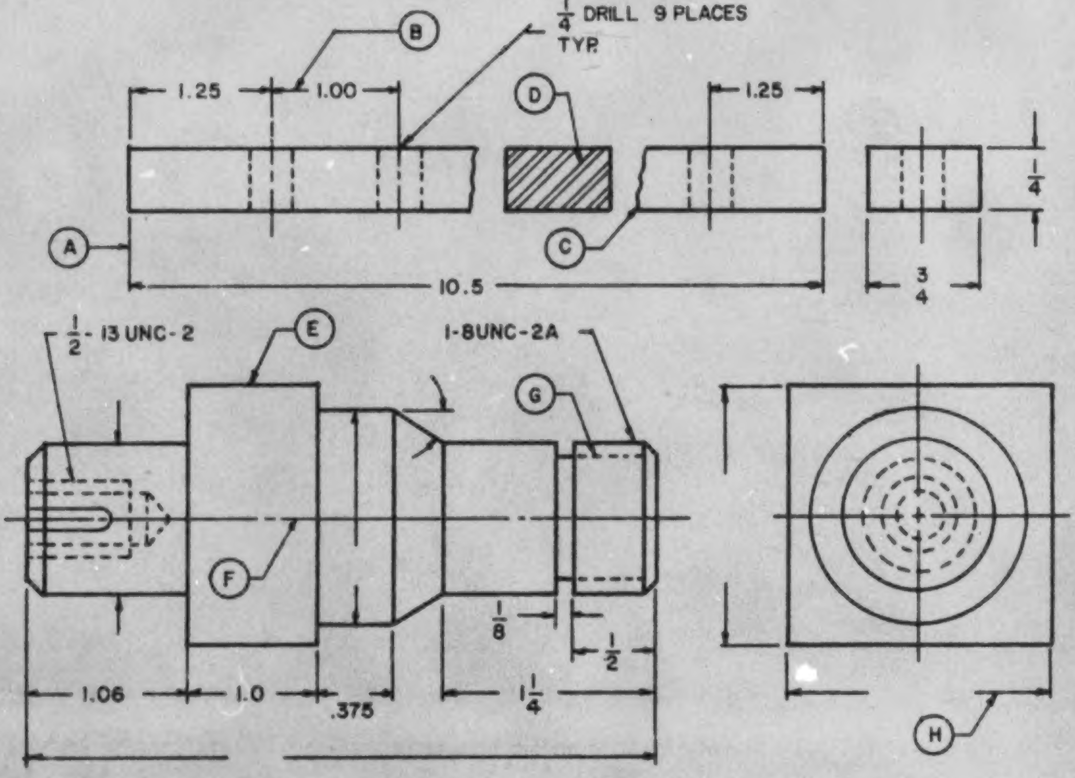
y. __________Unified National Fine

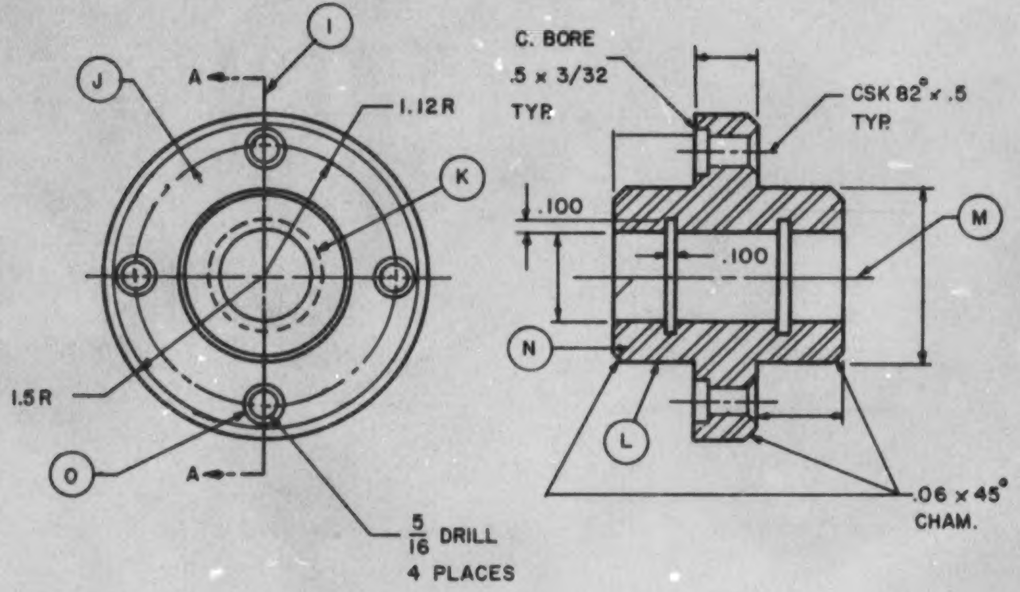
z. __________Unified National Special

aa. __________American Iron and Steel Institute

4. Identify the blueprint alphabet of lines in the drawings below and on the next page. Write the correct numbers in the blanks provided at the end. Answers may be used more than once.

   1. Object line
   2. Cutting plane line
   3. Dimension line
   4. Extension line
   5. Section line
   6. Hidden line
   7. Center line
   8. Leader
   9. Short break line


B
1/4 DRILL 9 PLACES
TYP.
1.25
1.00
D
1.25
1/4
A
C
10.5
3/4
1/2 - 13 UNC-2
E
1-8UNC-2A
G
F
1/8
1/2
1.06
1.0
.375
1 1/4
H


I
J
A
1.12R
K
1.5R
O
A
5/16 DRILL
4 PLACES
C. BORE
.5 x 3/32
TYP.
CSK 82° x .5
TYP.
.100
.100
M
N
L
.06 x 45°
CHAM.

a. ____________________

b. ____________________

c. ____________________

d. ____________________

e. ____________________

f. ____________________

g. ____________________

h. ____________________

i. ____________________

j. ____________________

k. ____________________

l. ____________________

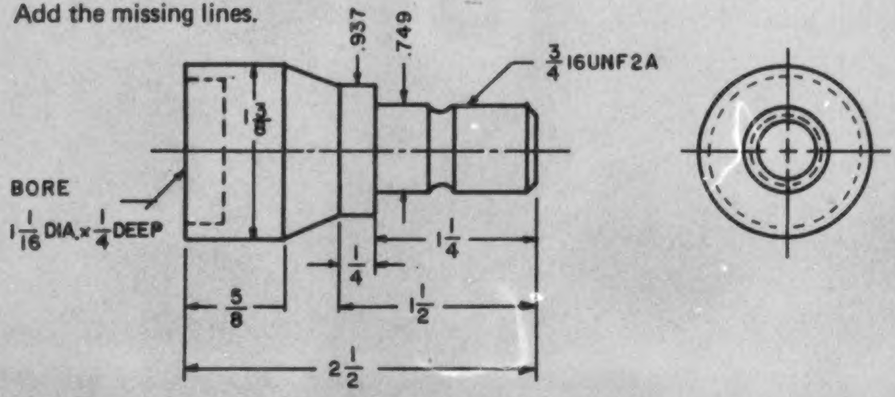
m. ____________________

n. ____________________

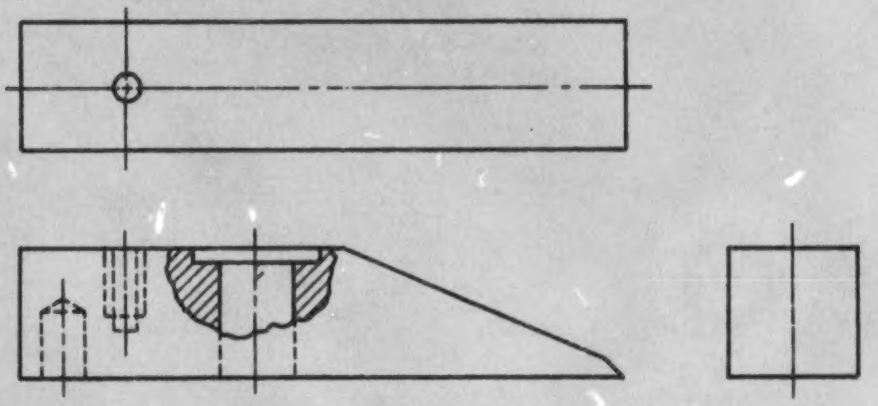
o. ____________________

5. Sketch orthographic projection drawings of the parts pictured below by completing the views or by drawing the missing view.

   a. Add the missing lines.


.937
.749
3/4 16UNF2A
1 3/8
BORE
1 1/16 DIA. x 1/4 DEEP
1/4
1 1/4
5/8
1 1/2
2 1/2

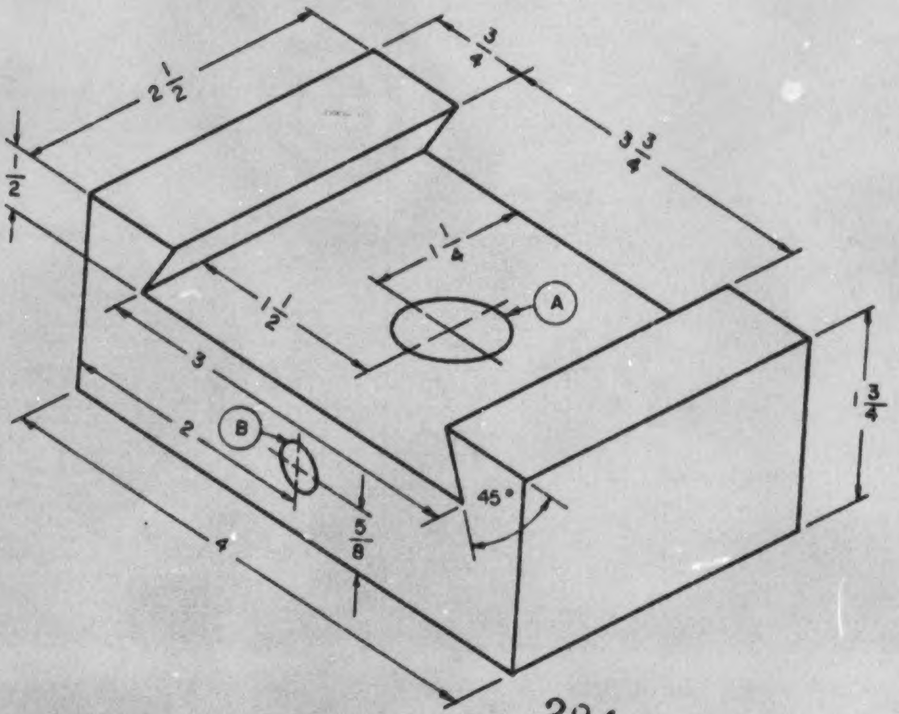
b. Complete the views below and add all missing object and hidden lines.



c. Make a three-view sketch of the part pictured below, using the space provided on the next page.

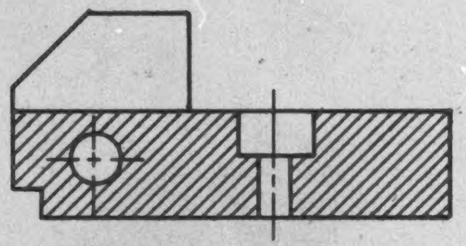
Note: Ⓐ 3/4" dia clear through

Ⓑ 3/8" dia 3/8" deep

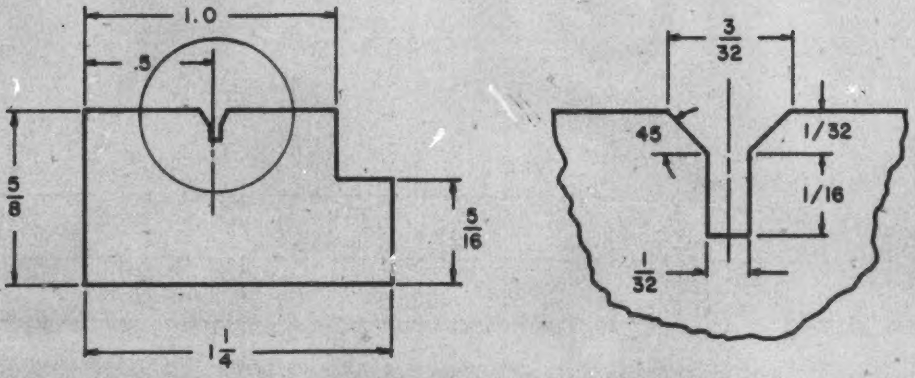

2 1/2
3/4
3 3/4
1/2
1 1/4
A
1 1/2
3
2
B
5/8
4
45°
1 3/4

6. Label types of views shown on a blueprint. Write the correct names in the blanks provided.

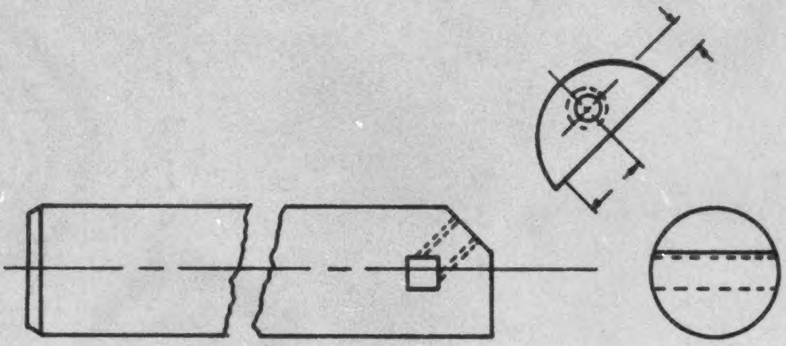
a. ______________________________



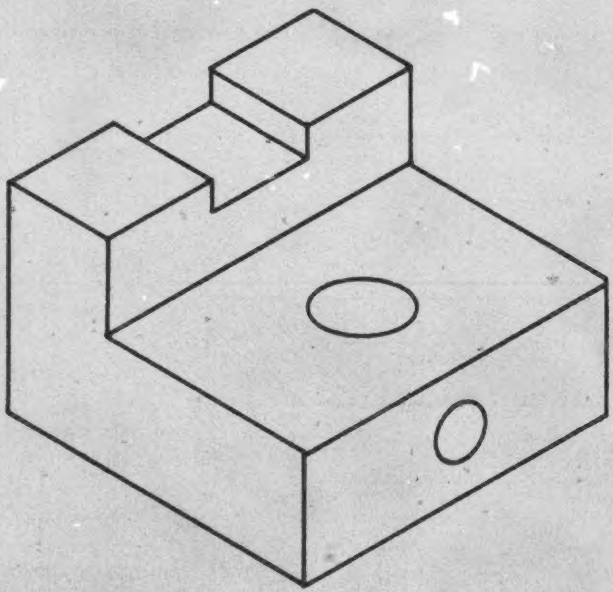
b. ______________________________


1.0
.5
5/8
5/16
1 1/4
3/32
45
1/32
1/16
1/32

c. ______________________



d. ______________________



7. Define dimension and tolerance.

a. Dimension-- ______________________

____

b. Tolerance-- ______________________

____

8. Identify industry methods of showing dimension and tolerance. Write the correct numbers in blanks provided.

______a. The size of a part before allowances and tolerances are applied

______b. The extreme permissible dimensions of a part resulting from use of tolerances

______c. Method of referencing dimensions where accurate machining is required

______d. Refers to the measured size of a part

______e. Points, surfaces, or lines from which references are made; indicated by letters with dashes on each side and enclosed in a small box

______f. Used for checking purposes; are without tolerances and not to be used for layout, machining, or inspection

______g. Used on drawings which contain datum lines

______h. Used to indicate the size of angles in degrees, minutes, and seconds

______i. Used when a series of parts is made that has the same shape, but different sizes; dimensions are replaced with letters

______j. Used to designate size for a commercial product; may or may not be the true size

______k. The intentional difference in the dimensioning of mating parts; provides different classes of fits

1. Datums
2. Linear dimensioning
3. Angular dimensions
4. Reference dimensions
5. Tabular dimensions
6. Arrowless dimensioning
7. Nominal size
8. Basic size
9. Allowance
10. Actual size
11. Limits

9. Select from a list types of information found in a blueprint title block. Mark an "X" beside the items you would find on a good industrial blueprint.

______a. Drawing name

______b. File number

______c. Size of material

______d. Who drew the blueprint

______e. Checked by

______f. Scale

______g. Material

______h. Special instructions

______i. Who designed the blueprint

______j. Date

______k. Revisions

______l. Finish

______m. Tolerance

______n. Approved by

______o. Dimensions

______p. Code identification number

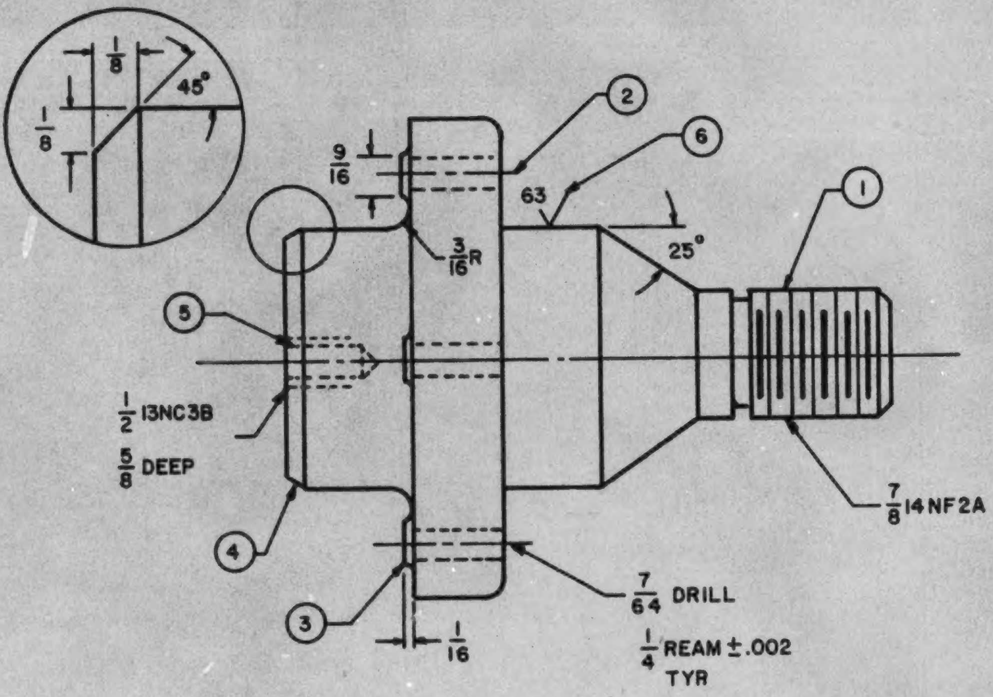
______q. Company manufacturer's name

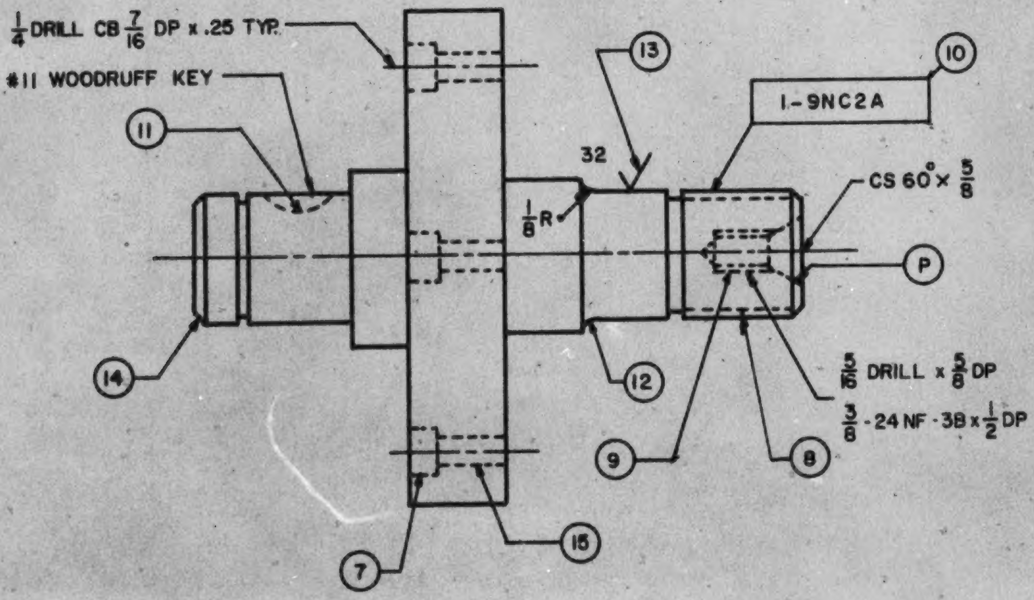
______r. Date required

______s. Number required

______t. Sheet

10. Interpret machine specifications and processes on the 2 drawings shown on the next page. Answer the questions that follow by writing the correct answers in the blanks provided.


$\frac{1}{8}$
45°
$\frac{1}{8}$
2
6
$\frac{9}{16}$
63
25°
1
$\frac{3}{16}$R
5
$\frac{1}{2}$ 13NC3B
$\frac{5}{8}$ DEEP
$\frac{7}{8}$ 14NF2A
4
$\frac{7}{64}$ DRILL
$\frac{1}{4}$ REAM ±.002
TYP.
3
$\frac{1}{16}$


$\frac{1}{4}$ DRILL CB $\frac{7}{16}$ DP x .25 TYP.
#11 WOODRUFF KEY
13
10
1-9NC2A
11
32
CS 60° x $\frac{5}{8}$
$\frac{1}{8}$R
P
14
12
$\frac{5}{16}$ DRILL x $\frac{5}{8}$ DP
$\frac{3}{8}$-24 NF-3B x $\frac{1}{2}$ DP
9
8
7
15

a. What is represented by number 1? ____________________

b. What is represented by number 2 and what is its size? ____________________

____

c. What is represented by number 3? ____________________

d. State the size and process represented by number 4. ____________________

e. What does number 6 represent? ____________________

f. What are the process and specifications represented by number 7? ____________________

____

g. What is represented by number 8? ____________________

h. What is represented by number 9? ____________________

i. What are the specifications for 10? ____________________

____

j. What are the specifications and process indicated by number 11? ____________________

____

k. What are the specifications and process indicated at 12? ____________________

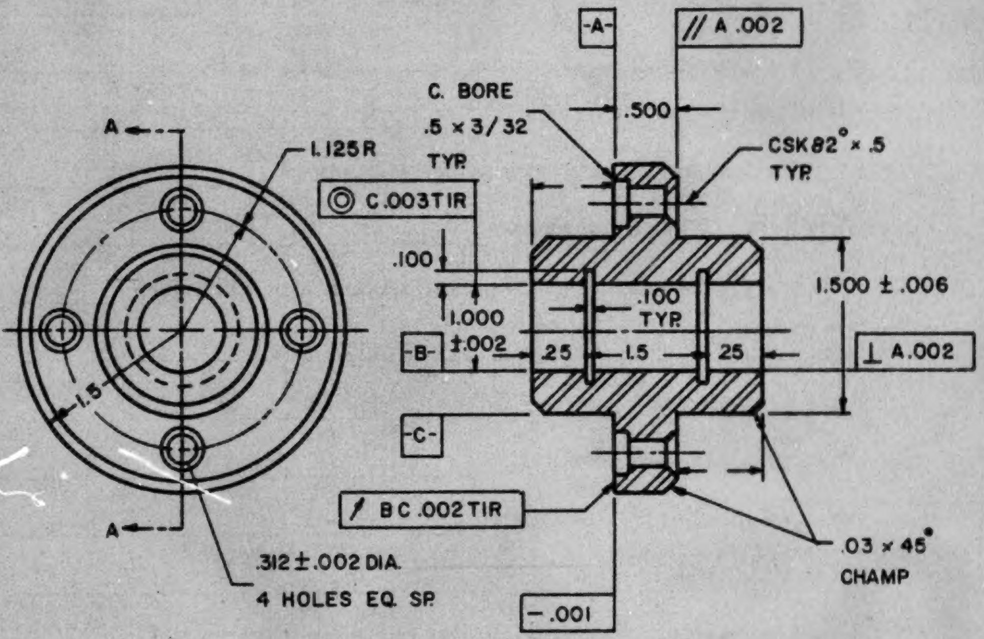
____

l. What is the specification represented by number 13? ____________________

m. What is the process indicated at 14? ____________________

n. What is indicated by number 15? ____________________

11. Read the industrial blueprints shown below and on the next page. Answer the questions that follow.


-A-
// A .002
C. BORE
.5 × 3/32
TYP.
.500
CSK 82° × .5
TYP.
A
1.125R
◎ C.003TIR
.100
1.000
±.002
.100
TYP.
1.500 ± .006
-B-
.25
1.5
.25
⊥ A.002
1.5
-C-
/ BC .002TIR
A
.312 ± .002 DIA.
4 HOLES EQ. SP.
— .001
.03 × 45°
CHAMP

a. What is the depth of the counterbored holes? ____________________

b. What is the diameter of the bolt hole circle? ____________________

c. What does ⊥ A.002 imply? ____________________

d. What is the tolerance of the 1" hole? Max. __________ Min. __________

e. What does // A.002 imply? ____________________

f. How flat and straight must -A- be? ____________________

g. What is the meaning of C.003TIR? ____________________

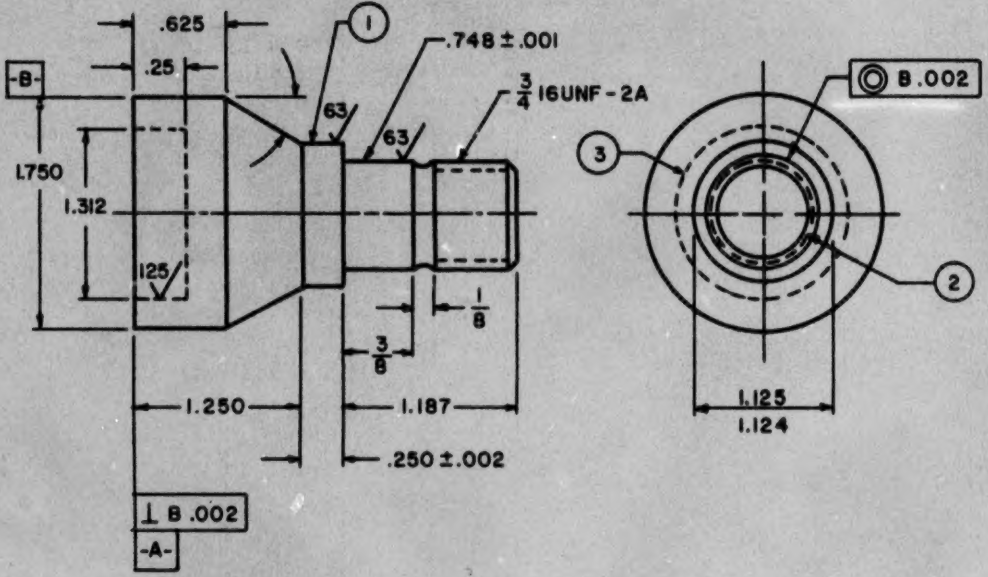
h. What is the size of the chamfers? ____________________

i. How much runout from datum -A- is allowed for datums -B- and -C- ? ____

____

j. What is the permitted variation in diameter of the equally spaced holes? ________

____



.625
.25
-B-
1
.748 ± .001
3/4 16UNF - 2A
63
63
1.750
1.312
125
3/8
1/8
1.250
1.187
.250 ± .002
⊥ B .002
-A-
◎ B .002
3
2
1.125
1.124

k. What is the tolerance of 1? ______

l. What does 2 represent? ______

m. What is the finish of the bore? ______

n. What is the overall length of the part? ______

o. What does 3/4 16UNF-2A mean? ______

______

p. What does ◎B.002 indicate? ______

q. What does 3 indicate? ______

r. What is the diameter of -B- ? ______

s. Is the part machined on all surfaces? ______

t. What is the perpendicular tolerance of -A- to -B- ? ______

BLUEPRINTS
UNIT II

ANSWERS TO TEST

(NOTE: The point system designated in parentheses is intended to be a guideline and should be adapted as needed. The point total is 300.)

1. (50 points)

   a. 6
   b. 1
   c. 2
   d. 7
   e. 8
   f. 5
   g. 11
   h. 12
   i. 10
   j. 9
   k. 3
   l. 4
   m. 15
   n. 16
   o. 17
   p. 13
   q. 14
   r. 19
   s. 22
   t. 24
   u. 20
   v. 18
   w. 25
   x. 21
   y. 23

2. (28 points)

   a. 4
   b. 7
   c. 5
   d. 1
   e. 3
   f. 6
   g. 2
   h. 11
   i. 8
   j. 13
   k. 12
   l. 9
   m. 10
   n. 14

3. (27 points)

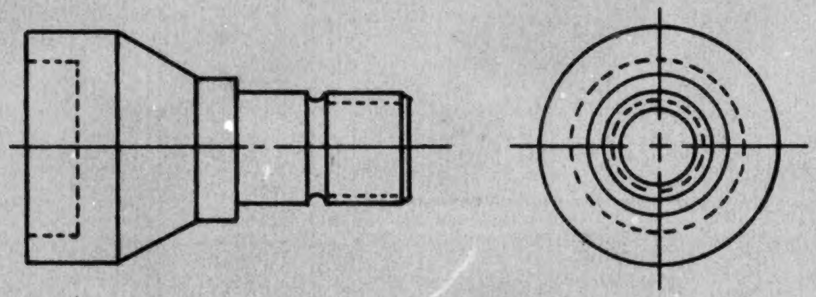
   a. CS
   b. SQ
   c. Hex
   d. R or Rad
   e. ID
   f. FS
   g. CRS
   h. F or Fin
   i. CSK
   j. CI
   k. C'Bore or CB
   l. CC
   m. FAO
   n. OC
   o. Dia
   p. SYM
   q. NTS
   r. SAE
   s. NPT
   t. USS
   u. TIR
   v. Par
   w. FSD
   x. UNC
   y. UNF
   z. UNS
   aa. AISI

4. (30 points)

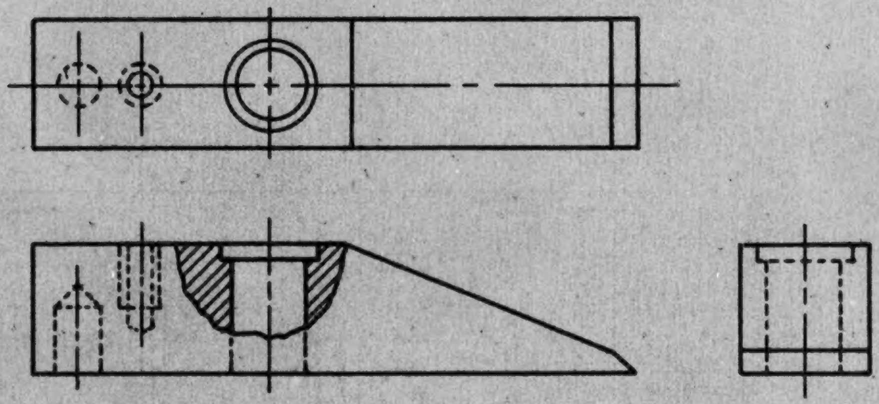
a. 4
b. 3
c. 9
d. 5
e. 1
f. 7
g. 6
h. 3
i. 2
j. 7
k. 6
l. 1
m. 7
n. 5
o. 1

5. (21 points)

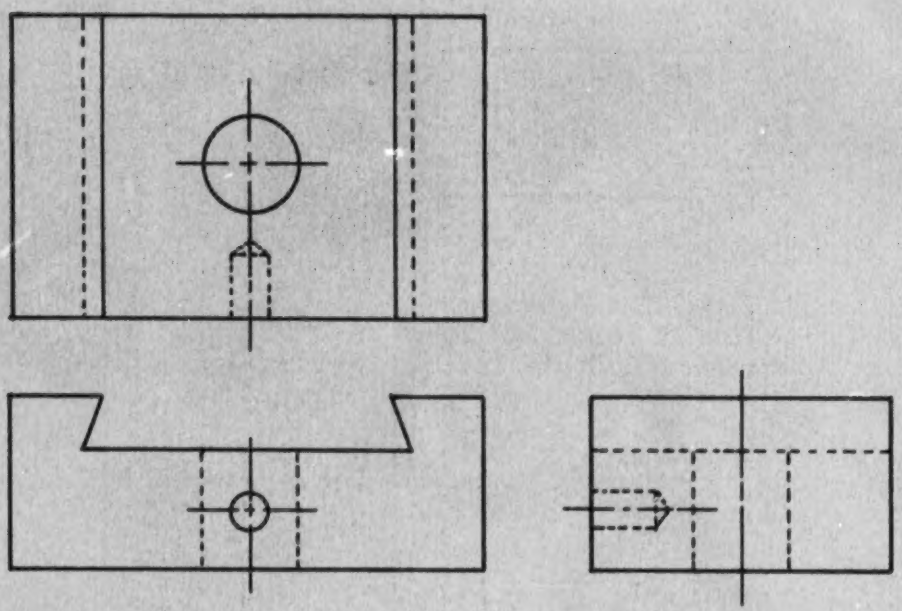
a.



b.



c.



6. (8 points)

a. Section view

b. Detail view

c. Auxiliary view

d. Isometric view

7. (6 points)

a. Dimension–Tells the size, shape, location of the holes and slots

b. Tolerance–The total amount of variation permitted in the size of a part

8. (22 points)

a. 8

b. 11

c. 2

d. 10

e. 1

f. 4

g. 6

h. 3

i. 5

j. 7

k. 9

9. (20 points)

b, d, e, f, i, k, m, n, p, r

10. (28 points)
    - a. External threads, 7/8" in diameter, 14 threads to inch, national form Class 2 fit
    - b. Center line, representing 7/64 drilled and 1/4 reamed hole
    - c. Boss
    - d. 1/8 x 1/8 x 45° chamfer
    - e. #63 finish
    - f. Counterbore 7/16 x .25 deep
    - g. External threads
    - h. Internal threads
    - i. External threaded part 1 inch in diameter, 9 threads per inch, national form coarse series, Class 2 fit, (A) External
    - j. #11 woodruff keyway
    - k. 1/8 fillet
    - l. #32 finish
    - m. Chamfer
    - n. 1/4" drilled hole

11. (60 points)
    - a. 3/32
    - b. 2.250
    - c. 1" bore is perpendicular to datum surface $\boxed{\text{-A-}}$ within .002
    - d. Max. 1.002 min. 1.000
    - e. The flange is parallel to $\boxed{\text{-A-}}$ within .002
    - f. .001
    - g. 1" bore must be concentric to $\boxed{\text{-C-}}$ within .003
    - h. .03
    - i. .002
    - j. .002
    - k. Max. 1.125 min. 1.124

l. Threads

m. 125√

n. 3.687

o. 3/4 dia., 16 threads per inch, Unified National Fine, Class 2 fit, External

p. Concentric to B within .002

q. Bore 1.312 shown in right side view as hidden line

r. 1.750

s. Yes - FAO

t. .002

RULES
UNIT III

UNIT OBJECTIVE

After completion of this unit, the student should be able to name the basic units of measurement, and read and use the common types of linear measuring tools. This knowledge will be shown by completion of assignment sheets, job sheets, and unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with linear measurement to the correct definitions.
2. Name the basic units of measurement found on steel rules.
3. Identify types of steel rules used in shop work.
4. Identify accessories used with steel rules.
5. Read steel rules.
6. Construct straight lines using steel rule.
7. Use steel rule to measure length of lines.
8. Demonstrate the ability to:
    a. Use steel rule.
    b. Use hook rule.
    c. Use steel rule to set caliper and divider.
    d. Use combination set.

RULES
UNIT III

SUGGESTED ACTIVITIES

I. Suggested activities for the instructor:

A. Provide students with objective sheet.

B. Provide students with information sheets.

C. Make transparencies.

D. Discuss unit and specific objectives.

E. Discuss information and assignment sheets.

F. Demonstrate and discuss procedures outlined in job sheets.

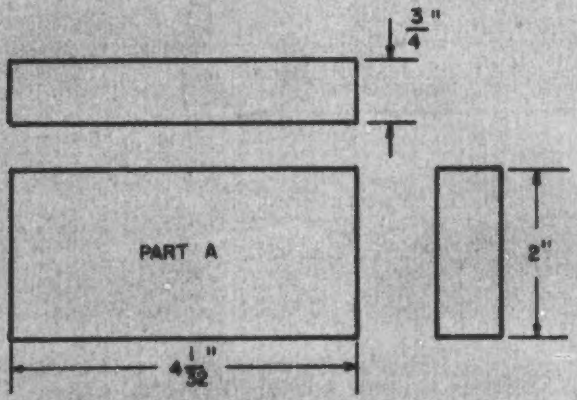
G. Have advanced students prepare measuring kits for use in job sheets.

1 each

Red	1/2"	C.R.S.	rod	2 1/2"	long
Blue	3/4"	C.R.S.	rod	3 5/32"	long
Green	1 3/16"	C.R.S.	rod	4 1/16"	long
Orange	1 3/4"	C.R.S.	rod	5 3/8"	long

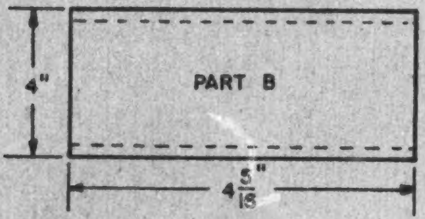
(NOTE: Machine C.R.S. rods to exact length described from diameters listed.)

-A- 4 1/32" steel bar 2" wide 3/4" thick

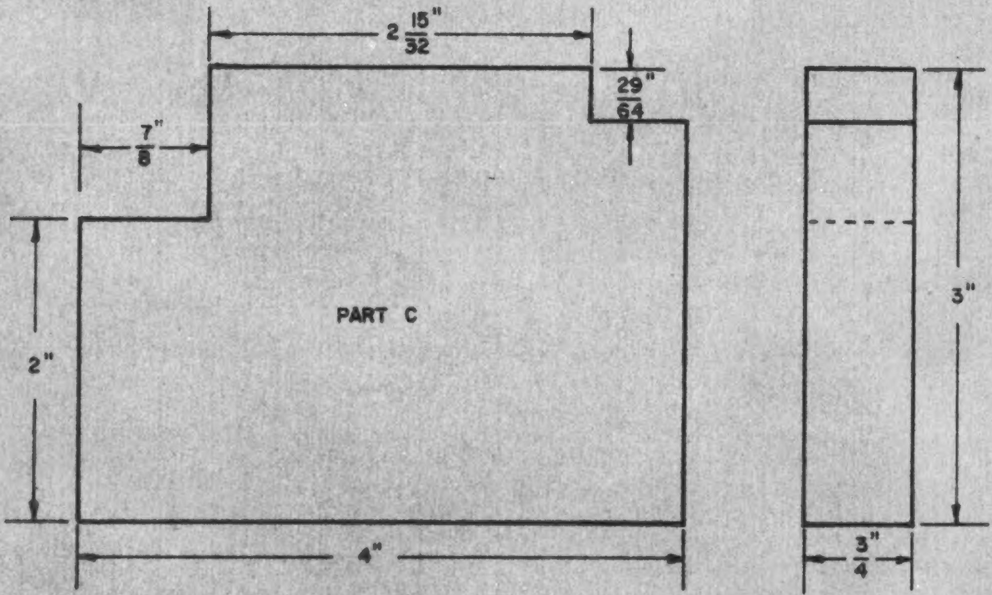


SUGGESTED ACTIVITIES

-B- 4" pipe exactly 4 5/16" long


4"
PART B
4 5/16"

-C- 3" steel bar 4" long 3/4" thick, machined as shown below:


2 15/32"
29/64"
7/8"
2"
PART C
4"
3"
3/4"

1 per student

1/8" x 4" x 5" steel or aluminum plate

H. Give test.

I. Reteach and retest if necessary.

SUGGESTED ACTIVITIES

II. Instructional materials:
  - A. Objective sheet
  - B. Information sheet
  - C. Transparency masters
    1. TM 1--Units of Measurement
    2. TM 2--Types of Rules
    3. TM 3--Uses of Rules
    4. TM 4--Uses of Rules (Continued)
    5. TM 5--Uses of Rules (Continued)
    6. TM 6--Uses of Spring Joint Calipers
    7. TM 7--Eighths Graduations
    8. TM 8--Sixteenths Graduations
    9. TM 9--Thirty-Seconds Graduations
    10. TM 10--Sixty-Fourths Graduations
  - D. Assignment sheets
    1. Assignment Sheet #1--Construct Straight Lines using Steel Rule
    2. Assignment Sheet #2--Use Steel Rule to Measure Length of Lines
  - E. Job sheets
    1. Job Sheet #1--Use Steel Rule
    2. Job Sheet #2--Use Hook Rule
    3. Job Sheet #3--Use Steel Rule to Set Caliper and Divider
    4. Job Sheet #4--Use Combination Set
  - F. Test
  - G. Answers to test

III. Unit reference: Kibbe, Richard R.; Neely, John E.; Meyer, Roland O.; and White, Warren T. *Machine Tool Practices*. New York: John Wiley and Sons, 1979.

RULES
UNIT III

INFORMATION SHEET

I. Terms and definitions

A. Steel rule--Non-precision measuring instrument graduated in fraction, decimal, or metric parts of units

(NOTE: Steel rules are often called "scales.")

B. Graduations--Markings found on rules; denote units of length

C. Error--A mistake in the reading or total measurement

D. Reliable measurement--An accurate or true measurement

E. Reference point--The starting point of measurement for both workpiece and rule

II. Basic units of measurement found on steel rules (Transparency 1)

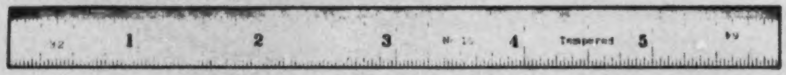
A. Fractional

B. Decimal

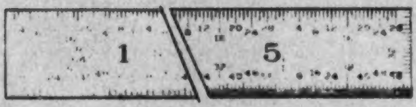
C. Metric

III. Types of steel rules used in shop work (Transparency 2)

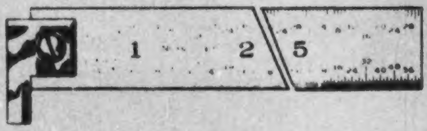
A. Narrow flexible rule



B. Steel rule

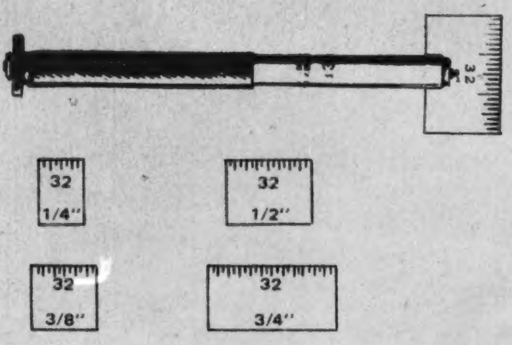


C. Hook Rule

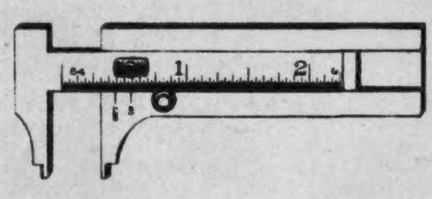


INFORMATION SHEET

D. Short rule with holder



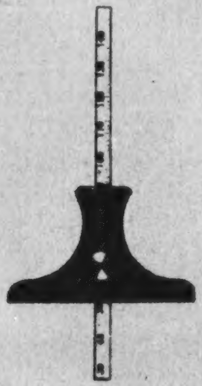
E. Slide caliper rule



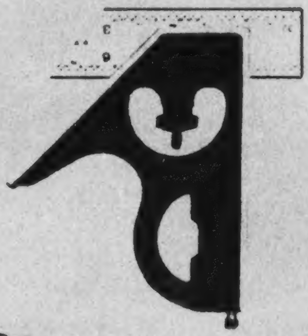
IV. Accessories used with steel rules (Transparencies 3-6)

(NOTE: Use of these accessories will be discussed in this unit, and in depth in the unit on hand tools.)

A. Depth gage

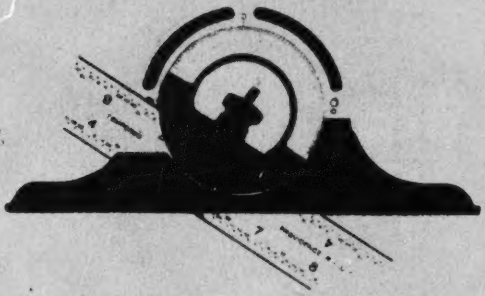


B. Square head

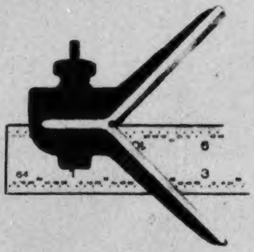


INFORMATION SHEET

C. Protractor head

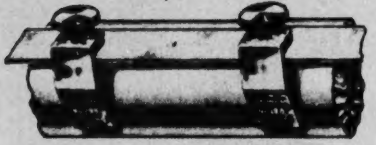


D. Center head

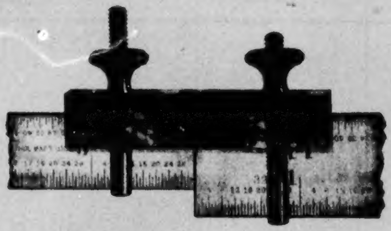


Used with permission of Brown and Sharpe Manufacturing Company

E. Key seat clamps

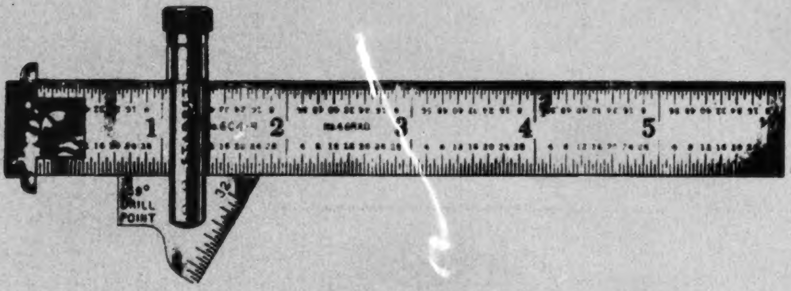


F. Rule clamps



Used with permission of the L. S. Starrett Company

G. Hook rule with drill point gage



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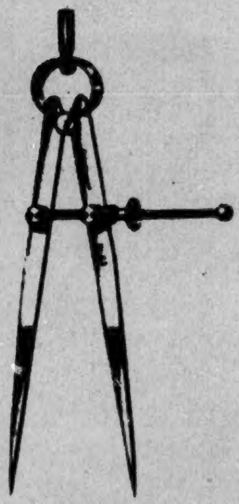
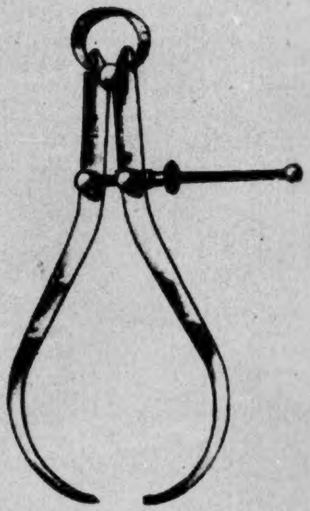
INFORMATION SHEET

H. Divider

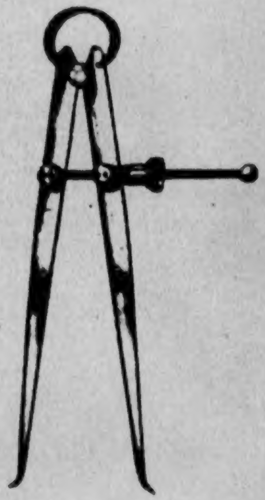


I. Calipers

1. Outside



2. Inside



V. Reading steel rules (Transparencies 7-10, Assignment Sheet #1)

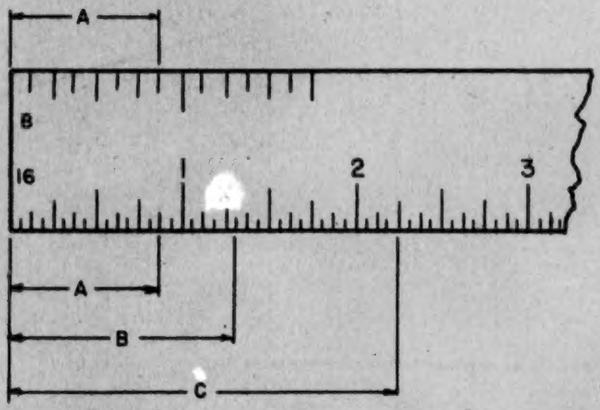
A. Examine the rule and the graduations on the rule

1. 1/8 graduations--Each inch is divided into eight equal parts, and each part equals 1/8 of an inch
2. 1/16 graduations--Each inch is divided into 16 parts, and each part equals 1/16 of an inch
3. 1/32 graduations--Each inch is divided into 32 equal parts, and each part equals 1/32 of an inch
4. 1/64 graduations--The one inch unit is divided into 64 parts, with each part equaling 1/64 of an inch
5. Decimal and metric rules--Each standard of measurement is divided into equal parts

INFORMATION SHEET

B. Always express the reading in its simplest form

Examples:



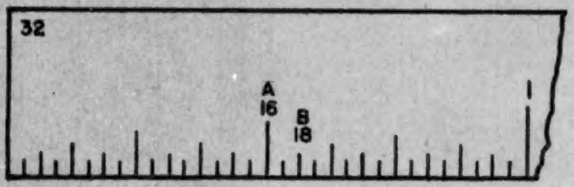
A = $\frac{14}{16}$ expressed as $\frac{7}{8}$ (seven eighths)

B = $1\frac{5}{16}$ expressed as $1\frac{5}{16}$ (one and five sixteenths)

C = $2\frac{4}{16}$ or $2\frac{2}{8}$ expressed as $2\frac{1}{4}$ (two and one fourth)

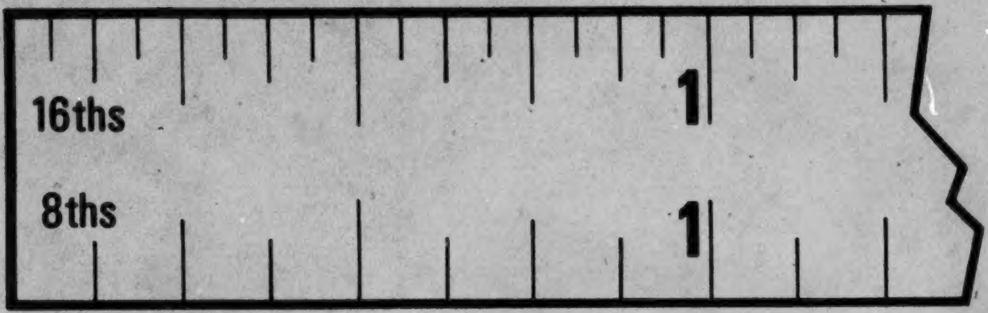
(NOTE: Some rules help by numbering the graduations of a particular scale.)

Examples:

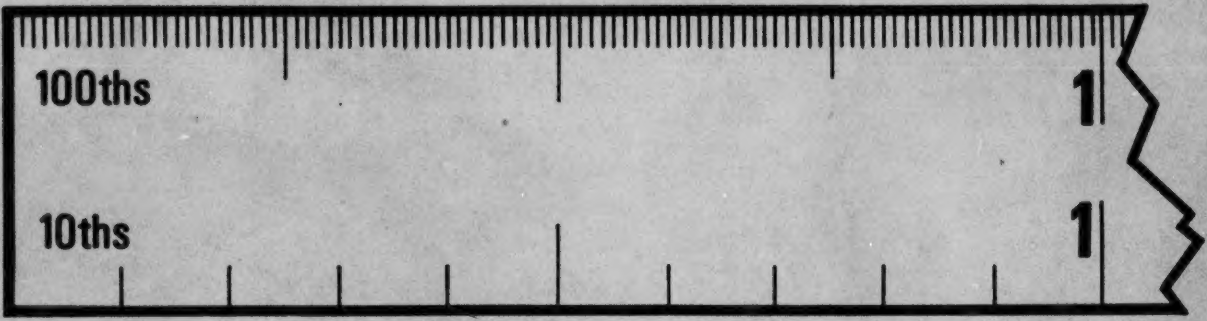


A: $\frac{16}{32} = \frac{1}{2}$ B: $\frac{18}{32} = \frac{9}{16}$

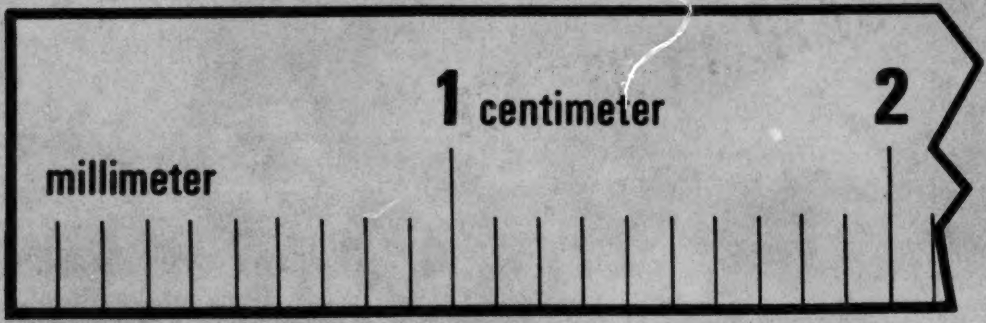
Units of Measurement


16ths
8ths
1
1

Fractional Rule

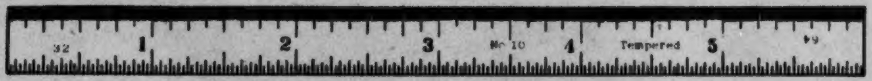

100ths
10ths
1
1

Decimal Rule


1 centimeter
2
millimeter

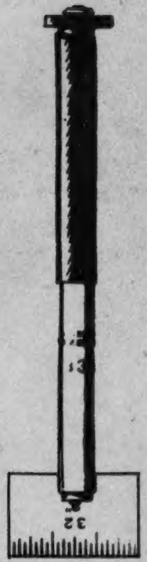
Metric Rule

Types of Rules

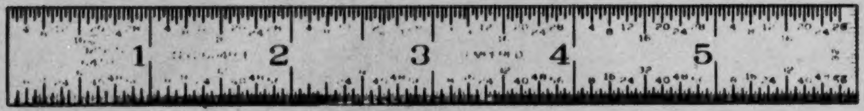


32
1
2
3
No 10
4
Tempered
5
64

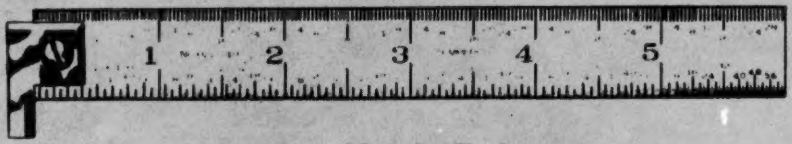
Narrow Flexible Rule



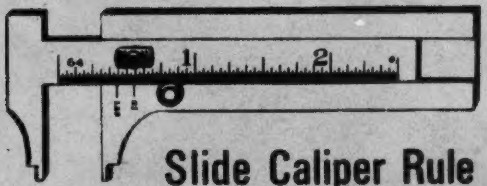
Short Rule with Holder



Steel Rule

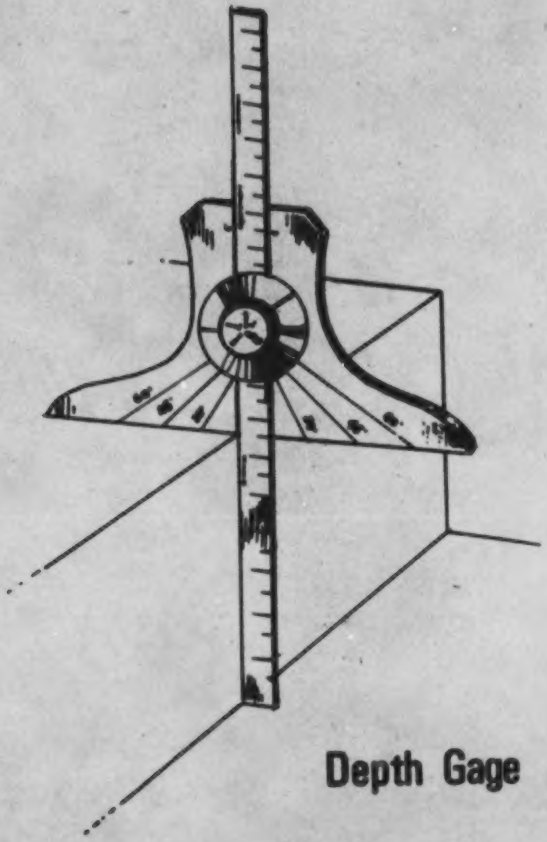


Hook Rule

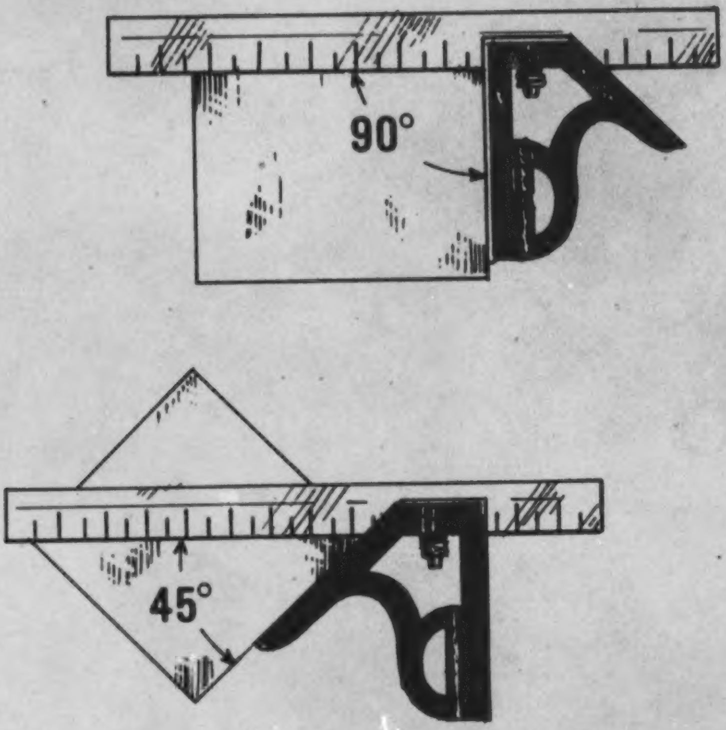


Slide Caliper Rule

Uses of Rules

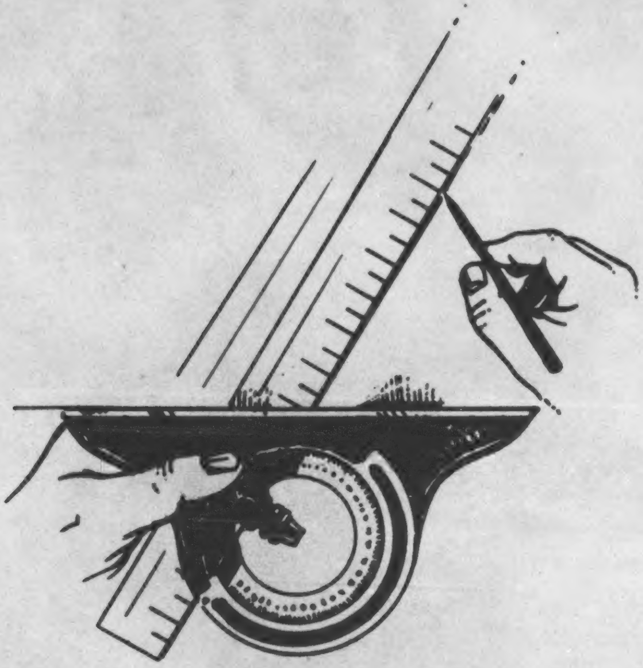


Depth Gage



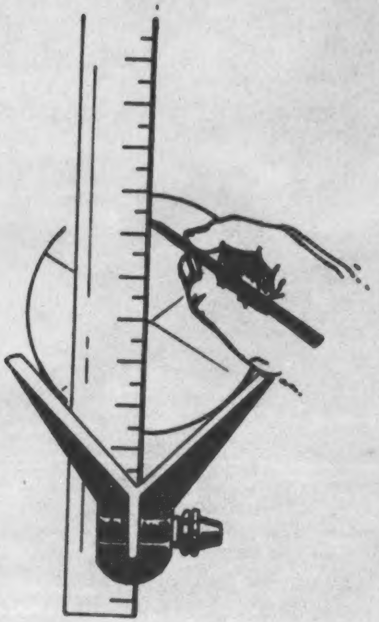
Combination Square

Uses of Rules
(Continued)



232

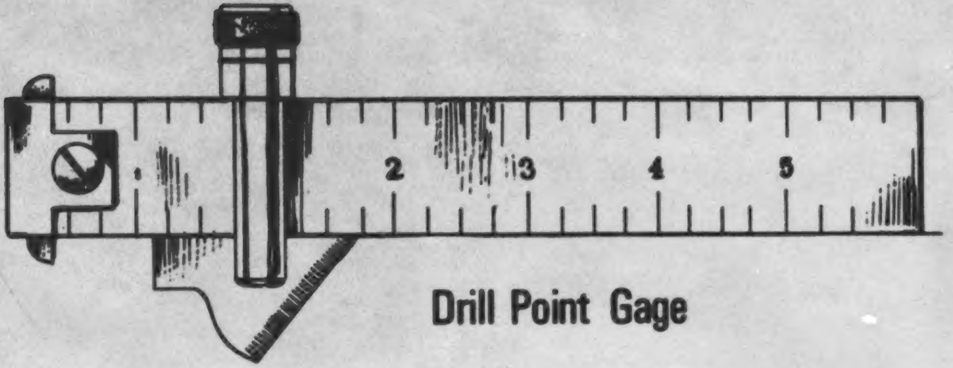
Bevel Protractor



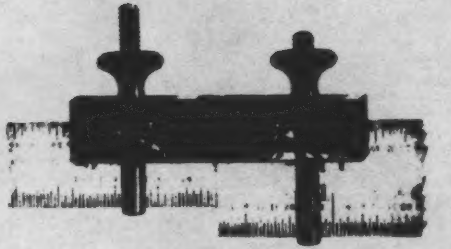
Center Head

233

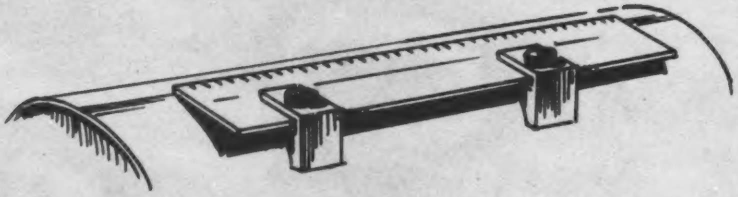
Uses of Rules
(Continued)



Drill Point Gage

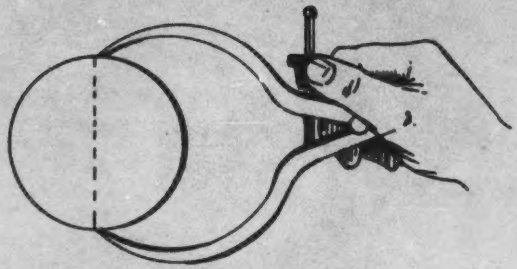


Rule Clamp

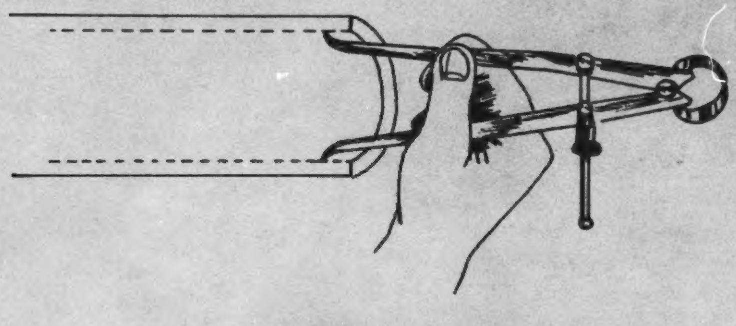


Key Seat Measurement

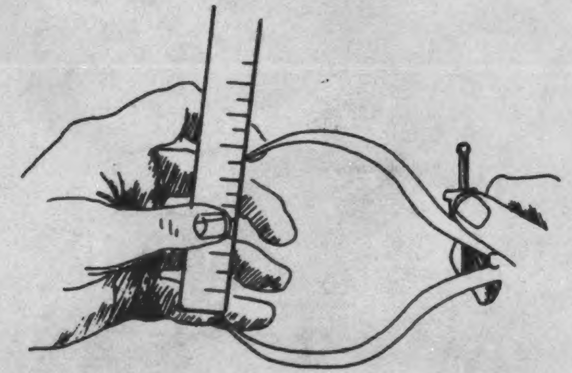
Uses of Spring Joint Calipers

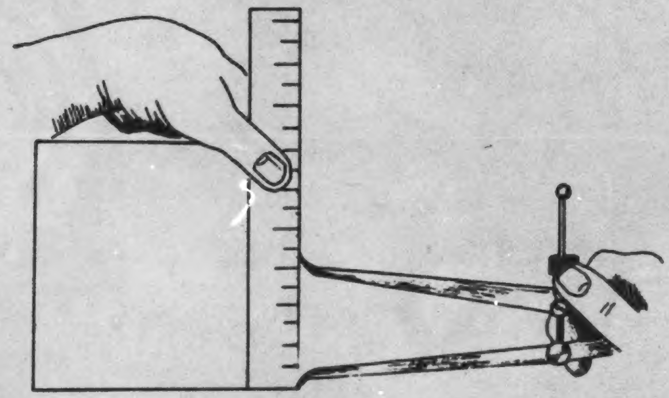


Outside Caliper

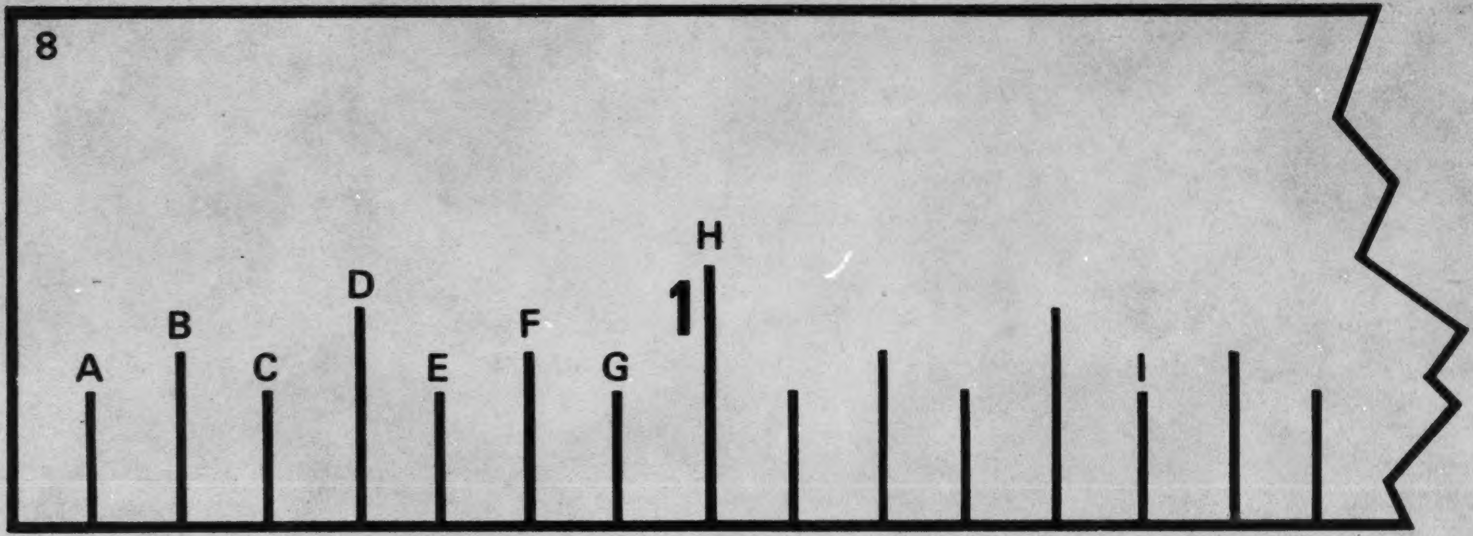


Inside Spring Joint Calipers



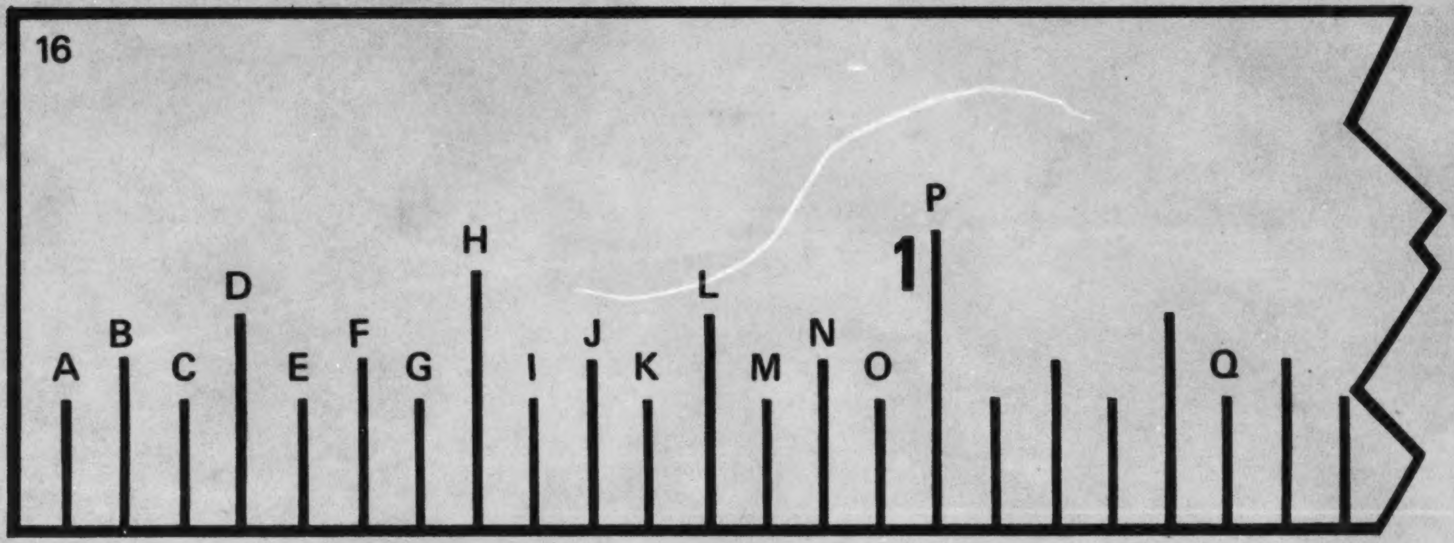


Eighths Graduations


8
A
B
C
D
E
F
G
1
H
I

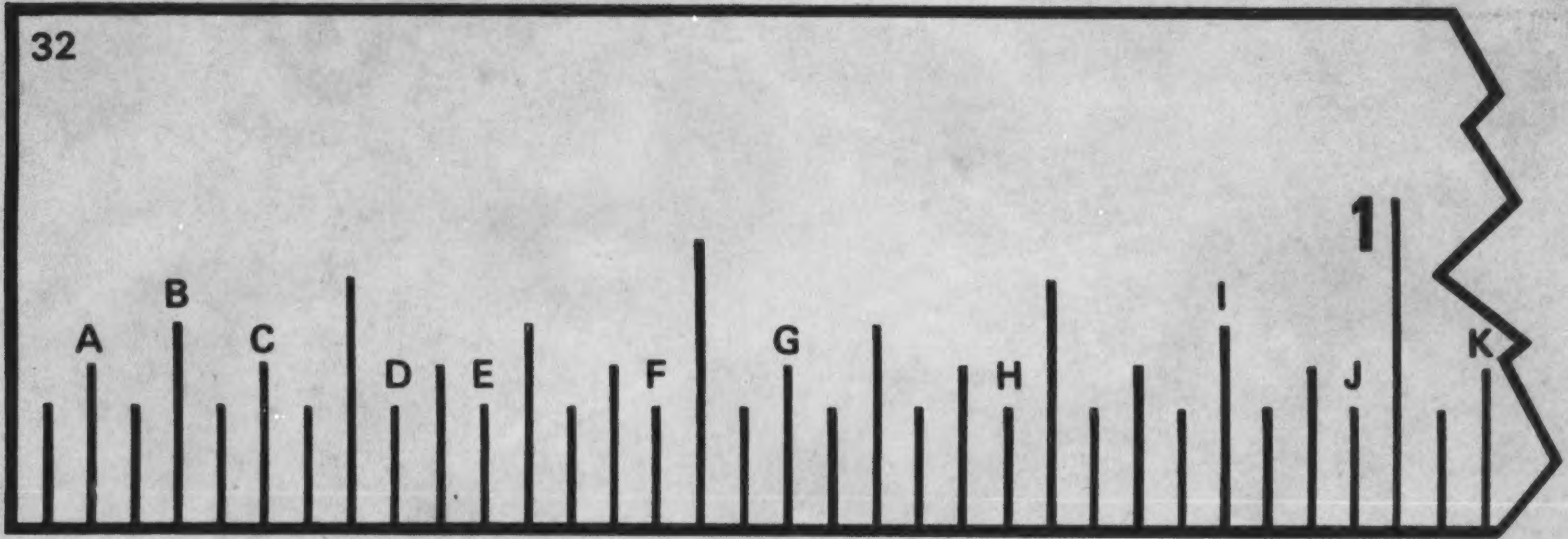
A = 1/8, B = 2/8 = 1/4, C = 3/8, D = 4/8 = 1/2,
E = 5/8, F = 6/8 = 3/4, G = 7/8, H = 8/8 = 1,
I = 13/8 = 1 5/8

Sixteenths Graduations


16
A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
1
P
Q

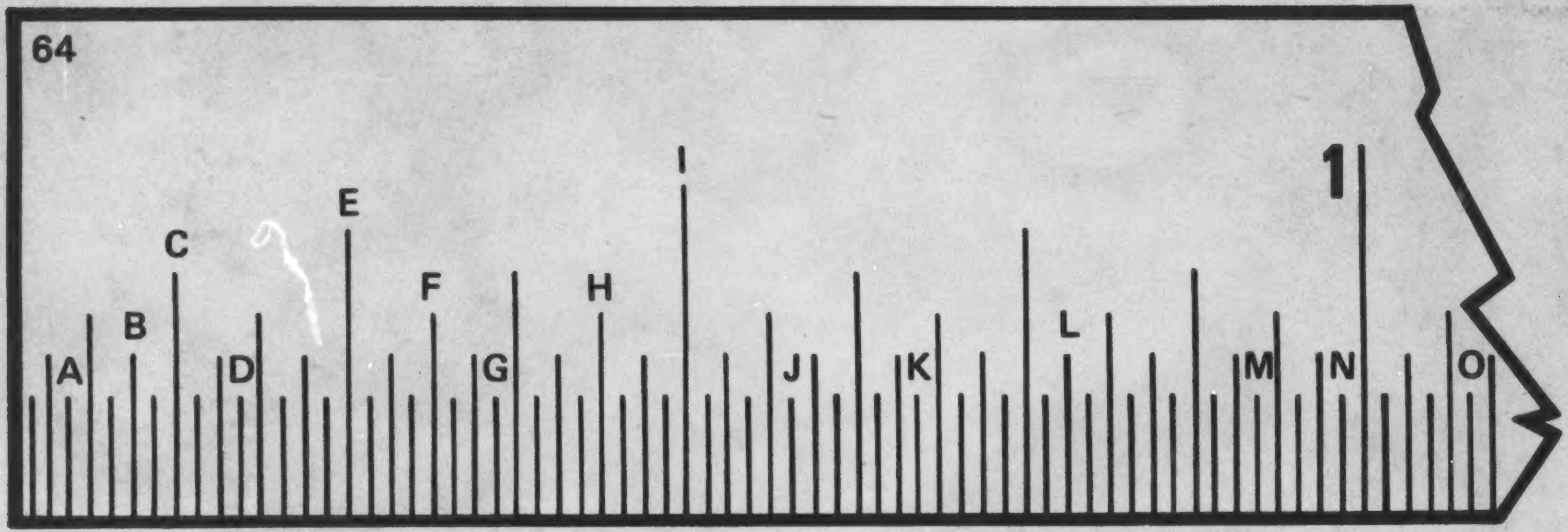
A = 1/16, B = 2/16 = 1/8, C = 3/16, D = 4/16 = 1/4,
E = 5/16, F = 6/16 = 3/8, G = 7/16, H = 8/16 = 1/2,
I = 9/16, J = 10/16 = 5/8, K = 11/16, L = 12/16 = 3/4,
M = 13/16, N = 14/16 = 7/8, O = 15/16, P = 16/16 = 1,
Q = 22/16 = 1 6/16 = 1 3/8

Thirty-Seconds Graduations


32
A
B
C
D
E
F
G
H
I
J
K
1

A = 2/32 = 1/16, B = 4/32 = 1/8, C = 5/32, D = 9/32,
E = 11/32, F = 15/32, G = 18/32 = 9/16, H = 23/32,
I = 28/32 = 14/16 = 7/8, J = 31/32,
K = 34/32 = 1 2/32 = 1 1/16

Sixty-Fourths Graduations


64
I
1
E
C
F
H
B
L
A
D
G
J
K
M
N
O

A = 3/64, B = 6/64 = 3/32, C = 8/64 = 1/8, D = 11/64,
E = 16/64 = 8/32 = 1/4, F = 20/64 = 10/32 = 5/16,
G = 23/64, H = 28/64 = 14/32 = 7/16, I = 32/64 = 1/2,
J = 37/64, K = 43/64, L = 50/64 = 25/32, M = 59/64,
N = 63/64, O = 69/64 = 1 5/64

RULES
UNIT III

ASSIGNMENT SHEET #1–CONSTRUCT STRAIGHT LINES USING STEEL RULE

NAME____________________________________ SCORE____________________

The steel rule is a very useful tool that can keep you from making mistakes if you learn how to read it quickly and accurately. The trained eye can be accurate to .005 of an inch.

PART I

Using a steel rule with 1/8, 1/16, 1/32, and 1/64 graduations, construct straight lines of the following lengths.

A. 2 1/4"

B. 3 1/2"

C. 4 1/8"

D. 2 7/8"

E. 1 5/16"

F. 2 7/32"

G. 3 47/64"

H. 2 15/16"

I. 1 19/32"

J. 3 3/64"

PART II

Using a steel rule that has a .1 and .01 scale, construct straight lines of the following lengths:

A. 1.5"

B. 2.25"

C. 4.1"

D. 3.42"

E. 2.08"

ASSIGNMENT SHEET #1

PART III

Using a steel rule that has metric graduations, construct straight lines of the following lengths:

A. 25.4mm

B. 38.4mm

C. 35.2mm

D. 78.7mm

E. 16.0mm

RULES
UNIT III

ASSIGNMENT SHEET #2--USE STEEL RULE TO MEASURE LENGTH OF LINES

NAME______________________________ SCORE______________

Reading measurements correctly is a must if you are to be a good machinist.

Use a steel rule with 1/8, 1/16, 1/32, and 1/64 graduations, and measure the length of the following lines. Write your answers on the measuring lines.

(NOTE: Express each length in its simplest form.)

A. ________________________

B. ______________

C. ________________________________

D. ________________________

E. ____________________________________

F. ________________________

G. _________

H. ___________________

I. __________________________

J. ___________________

RULES
UNIT III

JOB SHEET #1--USE STEEL RULE

I. Tools and equipment

A. 6 or 12" steel rule with 1/64 graduations

B. Measuring kit for steel rule

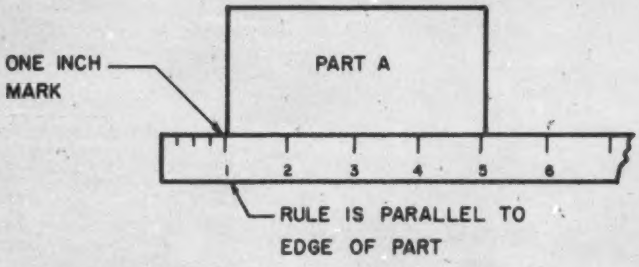
C. Magnifying glass

II. Procedure using Part A from measuring kit

A. Place the part on the bench and lay the steel rule on the part straight with the long side so the 1" mark is on one edge (Figure 1)

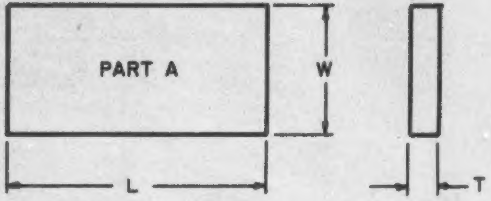
(NOTE: All dimensions on this job sheet are referenced from the 1" mark of the rule. It is easier to line that point up with the part than with the end of the rule. The end may be damaged, causing an error in measurement.)

FIGURE 1



B. Measure the length of the part, using the magnifying glass if necessary (See Figure 2); record your answer below

FIGURE 2



Answers L=_____ W=_____ T=_____

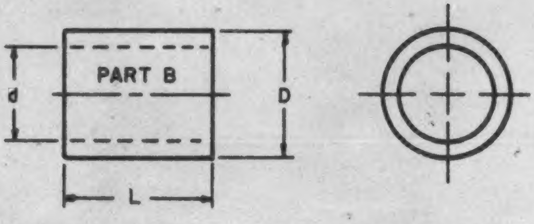
C. Repeat this procedure and measure lengths for W and T; record your answers

(NOTE: Did you subtract 1" from your readings?)

JOB SHEET #1

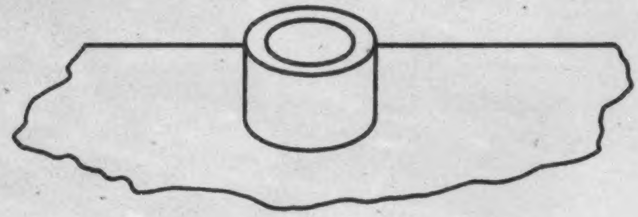
III. Procedure using Part B from measuring kit (Figure 3)

FIGURE 3



A. Place part on bench so round end is on bench (Figure 4)

FIGURE 4



B. Place edge of rule on part, using 1" mark as reference; then move other end of rule back and forth to find the maximum point or the greatest distance (Figures 5 and 6)

FIGURE 5

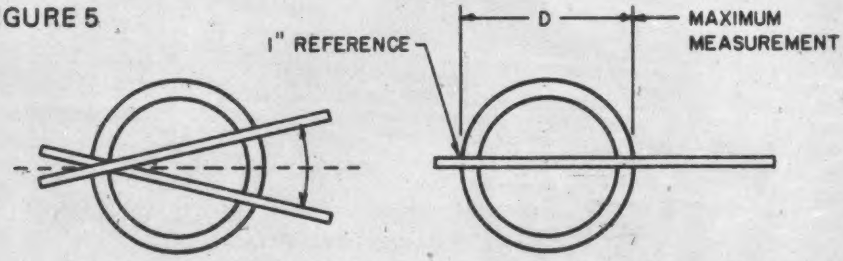
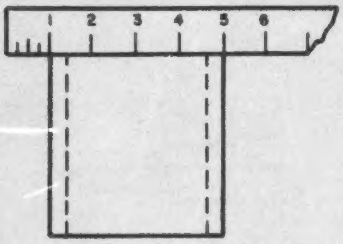

1" REFERENCE
D
MAXIMUM
MEASUREMENT

FIGURE 6



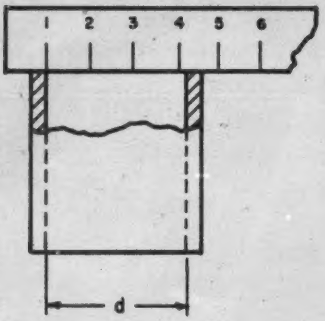
C. Record the reading D________________________

(NOTE: Subtract 1".)

JOB SHEET #1

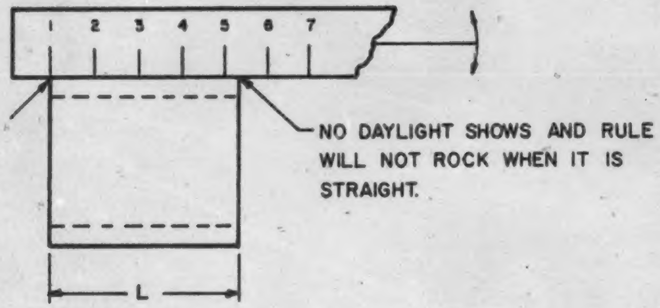
D. Measure the inside diameter in the same way, but put the 1" reference on the inside wall (Figure 7)

FIGURE 7



E. Lay the part down on the bench, laying the edge of the rule on the round side parallel to the length; set the 1" reference at one end (Figure 8)

FIGURE 8


1
2
3
4
5
6
7
NO DAYLIGHT SHOWS AND RULE WILL NOT ROCK WHEN IT IS STRAIGHT.
L

F. Record length L______________________________

(NOTE: Subtract 1".)

G. Keeping the 1" reference in place, move the rule back and forth until there is no daylight between the edge of the rule and the part

(NOTE: This insures that the measurement is reliable.)

H. Measure and record diameter and length for the following parts from the measuring kit

	D	L		D	L
Red	_____	_____	Green	_____	_____
Blue	_____	_____	Orange	_____	_____

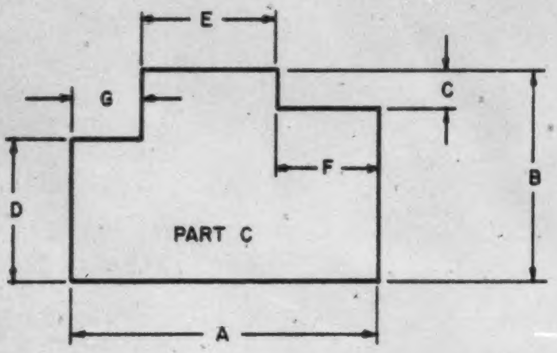
JOB SHEET #1

IV. Procedure using part C from the measuring kit (Figure 9)

A. Place the part on the bench using the 1" mark as a reference and measure distance (See Figure 7)

(NOTE: Make sure you keep the rule parallel to the direction you are measuring.)

FIGURE 9



B. Measure and record all distances a to g in the same manner

1. A = ______
2. B = ______
3. C = ______
4. D = ______
5. E = ______
6. F = ______
7. G = ______

RULES
UNIT III

JOB SHEET #2--USE HOOK RULE

I. Tools and equipment

  A. 6 or 12" hook rule with 1/64 graduations

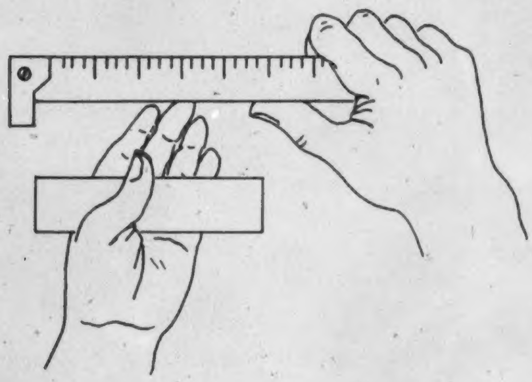
  B. Measuring kit for steel rule

  C. Magnifying glass

II. Procedure using part A

  A. Hold part in one hand and hold hook rule in other hand with hook down (Figure 1)

FIGURE 1



  B. Put rule down on the part with the hook over the end; move the rule back and forth until you have the minimum reading (Figures 2 and 3); record your measurement (See Step C)

FIGURE 2

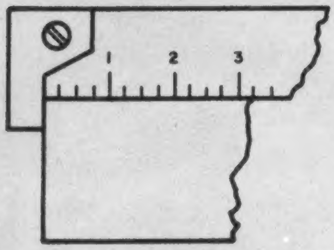
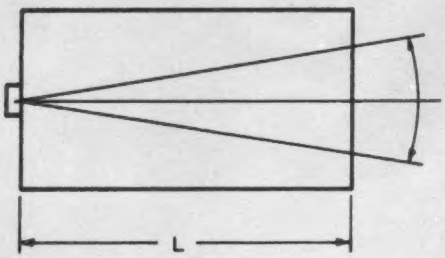


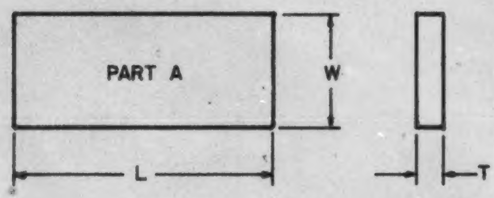
FIGURE 3



JOB SHEET #2

C. Repeat steps A and B above, measuring and recording dimensions L________ W______ and T______ (See Figure 4)

FIGURE 4



III. Procedure using part B

A. Place part B on bench so round end is on bench

B. Put rule down on part so hook is on edge of part; move the rule back and forth to obtain maximum dimension (Figures 5 and 6) Record ______

FIGURE 5

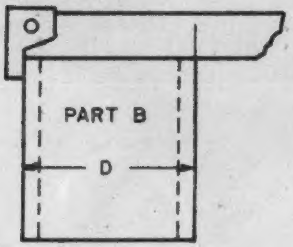
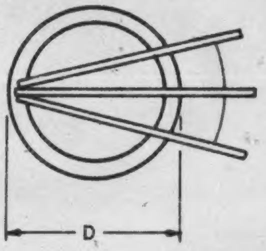


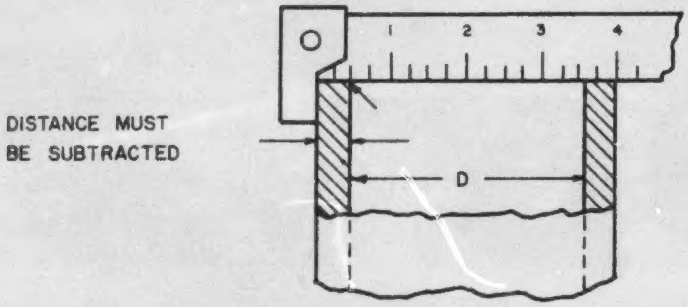
FIGURE 6



C. Using the same technique as above, record dimension d ___________ (Figure 7)

(NOTE: You must subtract the wall thickness. See Figure 7.)

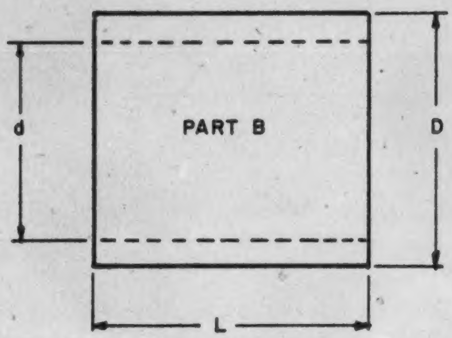
FIGURE 7


1
2
3
4
DISTANCE MUST
BE SUBTRACTED
D

JOB SHEET #2

D. Take dimension L and record_____ (Figure 8)

FIGURE 8



RULES
UNIT III

JOB SHEET # 3--USE STEEL RULE TO SET CALIPER AND DIVIDER

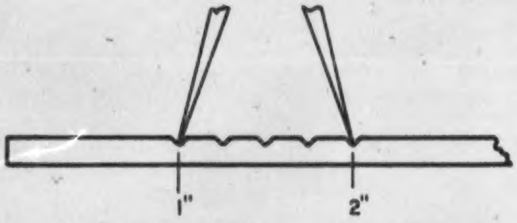
I. Tools and equipment

- A. 6 or 4" spring joint or firm joint caliper
- B. 6 or 4" spring joint divider
- C. 6 or 12" steel rule
- D. 4" x 4" x 3/16" aluminum plate with punch mark in center
- E. 2 1/2" round bar

II. Procedure for setting divider

A. Place the point of one of the divider legs in the 1" line of a ruler; then move the adjusting screw until the point of the other leg is exactly on the 2" line (Figure 1)

FIGURE 1



B. Move the divider to the center punch mark on the aluminum plate; with one end of the divider touching the center mark, scribe a circle

(NOTE: The circle will measure 2" from side to side.)

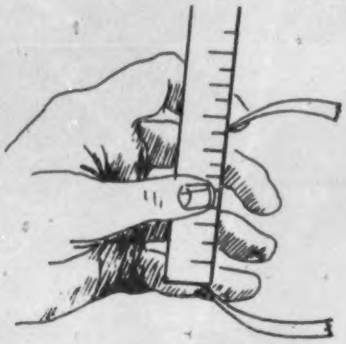
C. Repeating steps A and B, set the divider to 5/8", 1 3/16", and 1 15/32" sizes; scribe a circle each time

JOB SHEET #3

III. Procedure for setting outside caliper

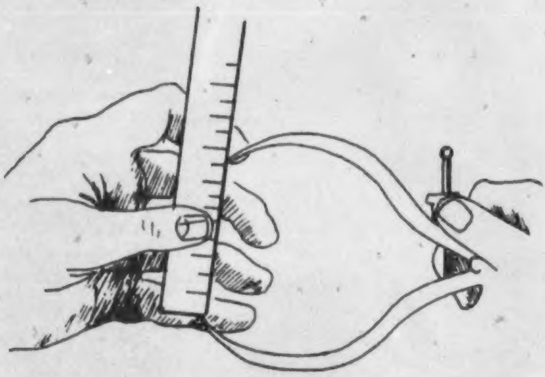
A. Hold a steel rule in one hand and the caliper in the other; place the bottom leg of the outside caliper on the steel rule (Figure 2)

FIGURE 2



B. Using the thumb of the hand holding the caliper, adjust the screw to length desired (Figure 3)

FIGURE 3



C. Repeating steps A and B, set the caliper on 2 1/2"; check your setting by sliding the outside caliper over a 2 1/2" C.R.S. bar

(NOTE: The size of the bar can vary ± .005.)

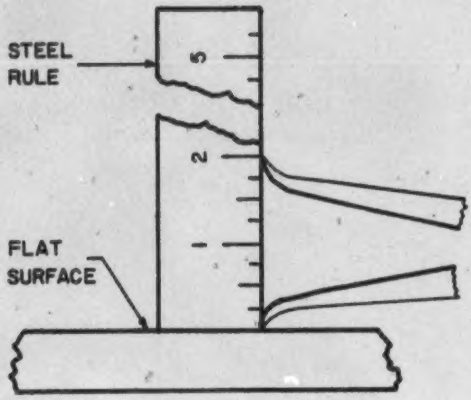
IV. Procedure for setting inside caliper

A. Place a steel rule on a flat surface, holding it upright (See Figure 4)

JOB SHEET #3

B. Set one leg of the caliper on the same flat surface, and adjust the other leg to 2 5/8" (Figure 4)

FIGURE 4


STEEL RULE
5
2
1
FLAT SURFACE

C. Set inside calipers at 2 5/8"

(NOTE: The caliper must be parallel to the flat surface to get a true setting.)

RULES
UNIT III

JOB SHEET #4--USE COMBINATION SET

I. Tools and equipment

- A. 12" combination set
- B. 4" by 5" steel or aluminum plate, 1/8" thick
- C. Layout fluid
- D. 3" C.R.S. round bar 4" long

II. Procedure using steel rule and square head

A. Apply a thin coat of layout fluid to one side of the material with applicator or rag

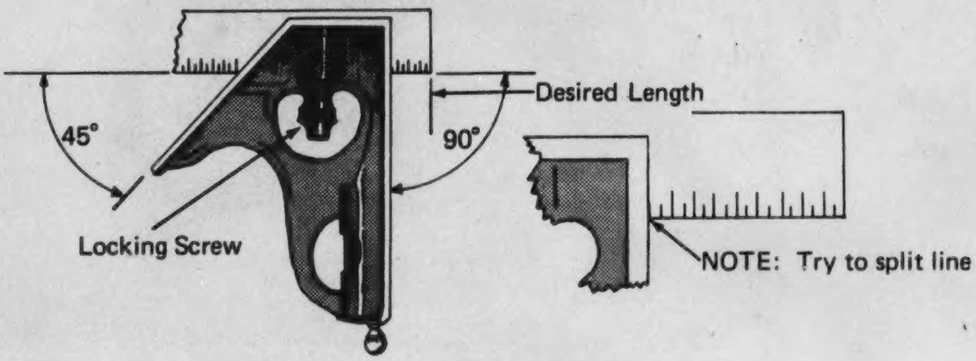
(NOTE: You are not printing; you need only enough of this fluid to take the shine off the material. If fluid is applied too heavily it will flake off when you scribe your lines.)

(CAUTION: Do not get this fluid on your clothes as it *will not* wash out. Use in a well ventilated area.)

B. Put cap back on layout fluid container tightly; allow fluid to dry thoroughly before proceeding

C. Set lengths by loosening the locking screw and sliding the rule out to the desired length; tighten lock screw (Figure 1)

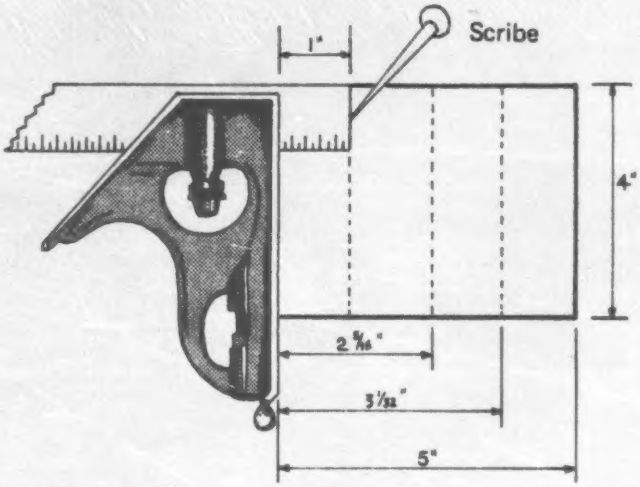
FIGURE 1



JOB SHEET #4

D. Set and layout the following lengths along the 4" side: 1", 2 5/16", and 3 1/32"; scribe lines as a solid line (Figure 2)

FIGURE 2



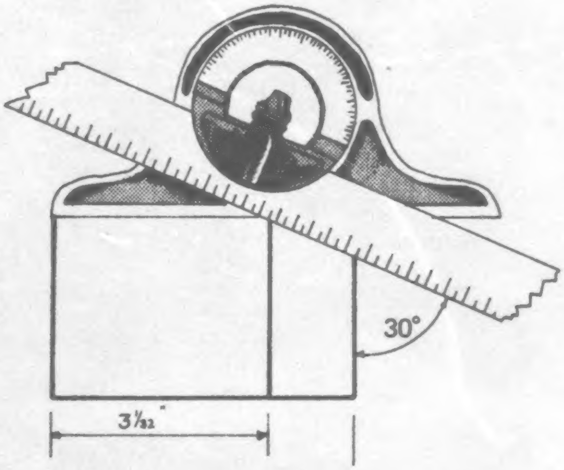
(NOTE: The dotted lines are for illustration purposes.)

III. Procedure using steel rule and protractor

A. Loosen the two lock screws that allow you to set the desired angle (0° - 180°); retighten lock screw and adjust rule (blade) to the correct length

B. Set rule and scribe a 30° angle, using the 5" side as reference and the 3 1/32" line marked above (Figure 3)

FIGURE 3



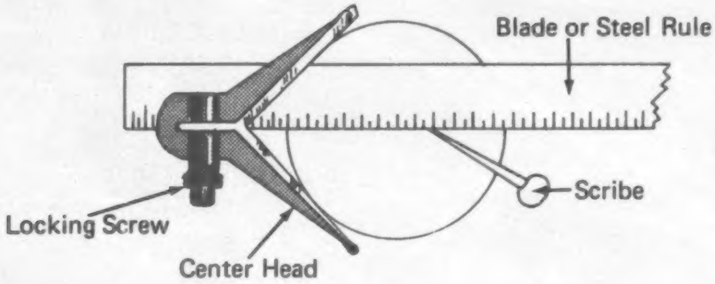
JOB SHEET #4

IV. Procedure using steel rule and center head

(NOTE: The purpose of the adjustment is to mark lines through the center of round parts.)

A. Using the 3" steel bar, hold the "V" portion of the center head to the side of the part; scribe a line through the center of the round surface (Figure 4)

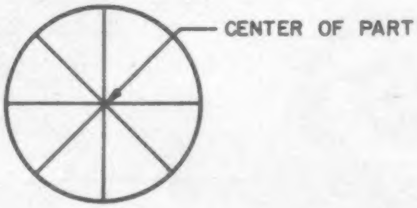
FIGURE 4


Blade or Steel Rule
Scribe
Locking Screw
Center Head

B. Rotate the head around the part three or four times and scribe intersecting lines

(NOTE: The intersection of the lines is the center of the part. See Figure 5.)

FIGURE 5


CENTER OF PART

RULES
UNIT III

TEST

NAME_______________________________________ SCORE_________________

1. Match terms associated with linear measurement to the correct definitions. Write the correct numbers in the blanks provided.

_____a. A mistake in the reading or total measurement

_____b. The starting point of measurement for both workpiece and rule

_____c. Markings found on rules; denote units of length

_____d. An accurate or true measurement

_____e. Non-precision measuring instrument graduated in fraction, decimal, or metric parts of units

1. Steel rule
2. Graduations
3. Error
4. Reliable measurement
5. Reference point

2. Name the basic units of measurement found on steel rules.

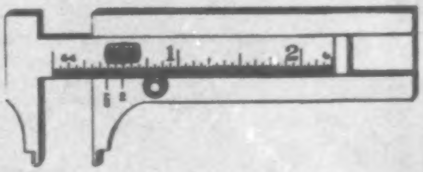
a. ____

b. ____

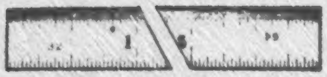
c. ____

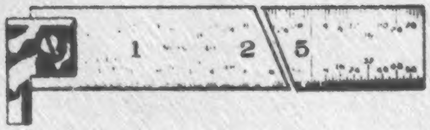
3. Identify types of steel rules used in shop work from the illustrations shown below and on the next page. Write the correct numbers in the blanks provided.

1. Steel rule
2. Hook rule
3. Short rule with holder
4. Narrow flexible rule
5. Slide caliper rule

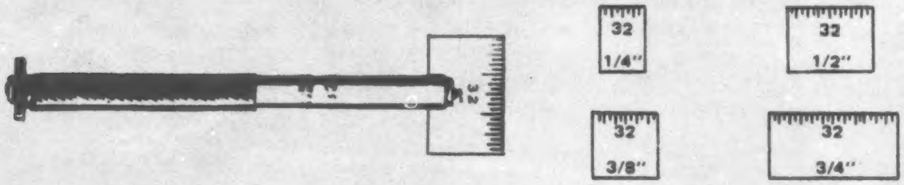


a. ____

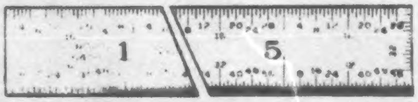




b. ______________________ c. ______________________


32
32
1/4"
32
1/2"
32
3/8"
32
3/4"

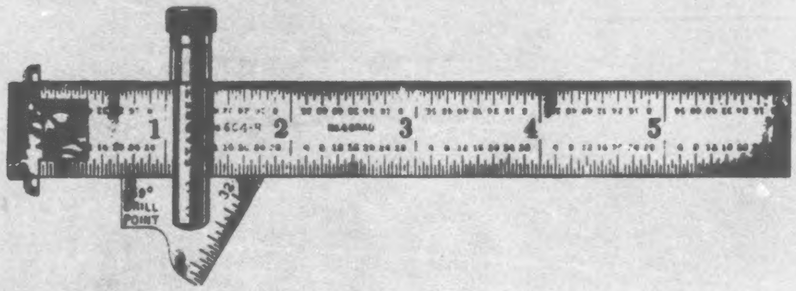
d. ______________________



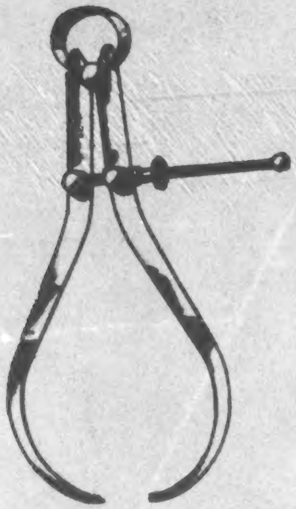
e. ______________________

4. Identify accessories used with steel rules as seen in the following illustrations. Write the correct numbers in the blanks provided.

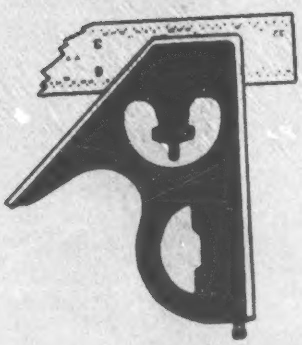
1. Depth gage
2. Square head
3. Protractor head
4. Center head
5. Hook rule with drill point gage
6. Key seat clamps
7. Rule clamps
8. Divider
9. Outside caliper
10. Inside caliper


1
2
3
4
5
59°
DRILL
POINT
32

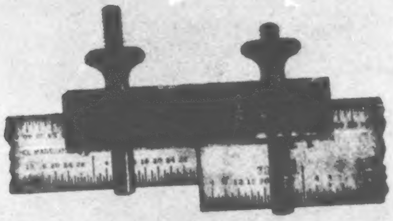
a. ______________________



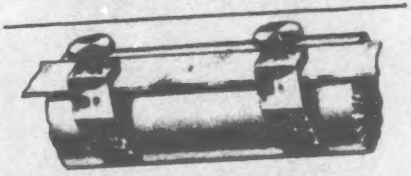
b. ____________________



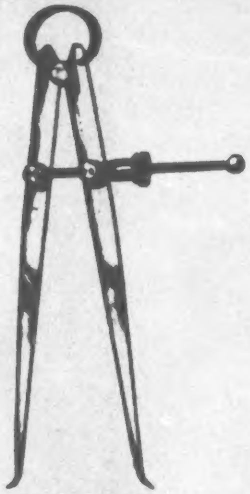
c. ____________________



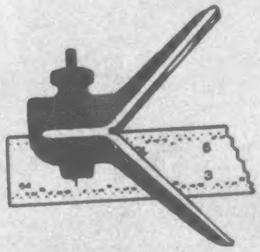
d. ____________________



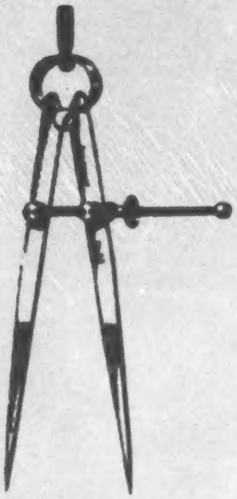
e. ____________________



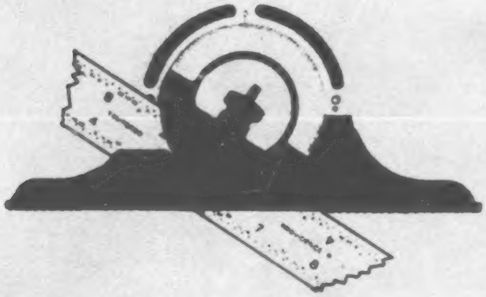
f. ____________________



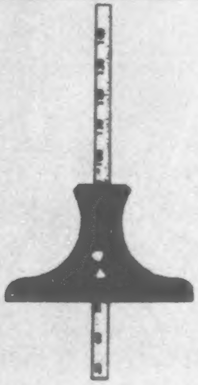
g. ____________________



h. ____

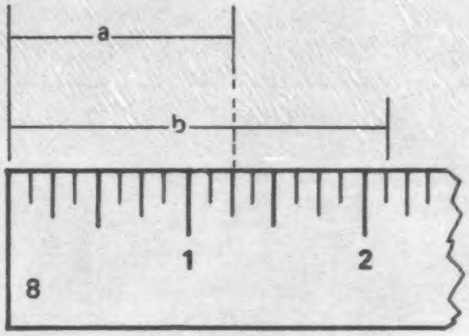


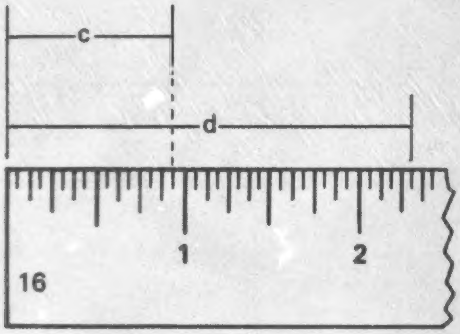
i. ____

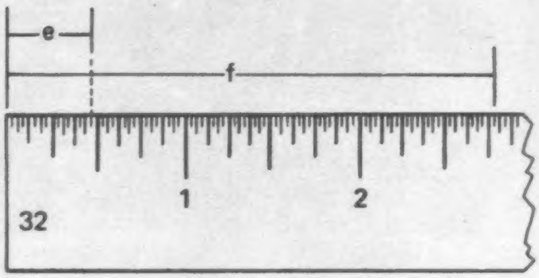


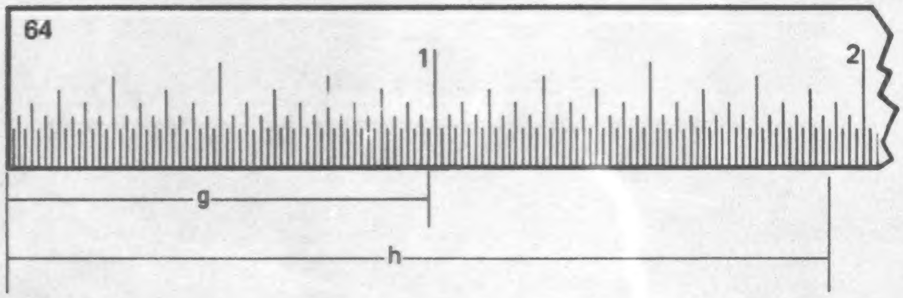
j. ____

5. Read steel rules. Write the correct measurements in the blanks provided. Be sure to express fractions in simplest form.









a. ____________________

b. ____________________

c. ____________________

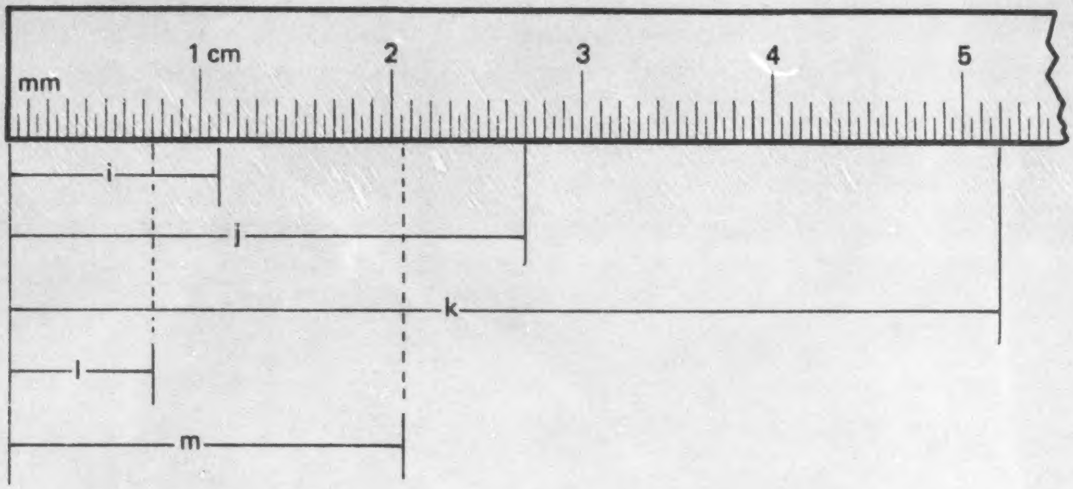
d. ____________________

e. ____________________

f. ____________________

g. ____________________

h. ____________________


mm
1 cm
2
3
4
5
i
j
k
l
m

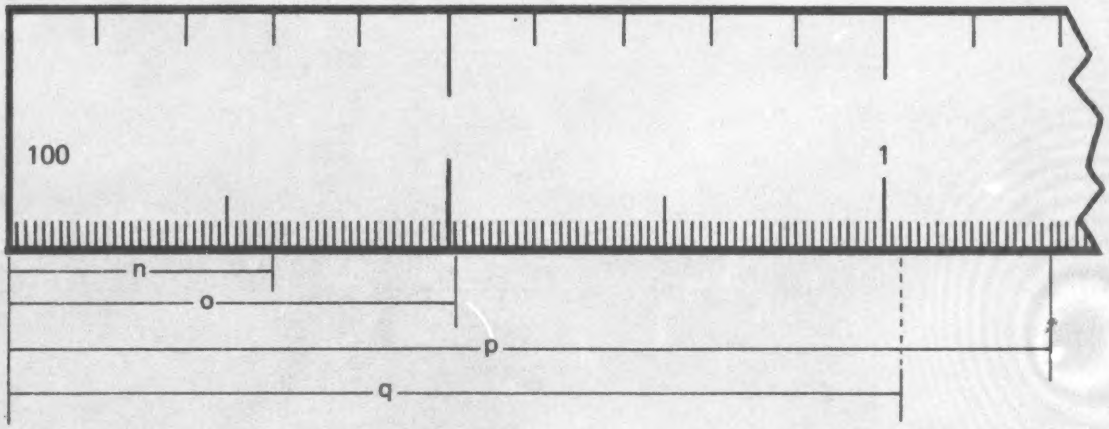
i. ____________________

j. ____________________

k. ____________________

l. ____________________

m. ____________________



n. ____________________

o. ____________________

p. ____________________

q. ____________________

6. Construct straight lines using steel rule.
7. Use steel rule to measure length of lines.
8. Demonstrate the ability to:
    - a. Use steel rule.
    - b. Use hook rule.
    - c. Use steel rule to set caliper and divider.
    - d. Use combination set.

    (NOTE: If activities 6-8 have not been finished before the test, ask your instructor when they should be completed.)

RULES
UNIT III

ANSWERS TO TEST

(NOTE: The point system in parentheses is intended to be a guideline and should be adapted as needed. The point total is 300.)

1. (10 points)
    - a. 3
    - b. 5
    - c. 2
    - d. 4
    - e. 1
2. (6 points)
    - a. Fractional
    - b. Decimal
    - c. Metric
3. (10 points)
    - a. 5
    - b. 4
    - c. 2
    - d. 3
    - e. 1
4. (20 points)
    - a. 5
    - b. 9
    - c. 2
    - d. 7
    - e. 6
    - f. 10
    - g. 4
    - h. 8
    - i. 3
    - j. 1
5. (34 points)
    - a. 1 1/4
    - b. 2 1/8
    - c. 15/16
    - d. 2 5/16
    - e. 15/32
    - f. 2 25/32
    - g. 63/64
    - h. 1 59/64

i. 11mm

j. 27mm

k. 52mm

l. 7.5mm

m. 20.5mm

n. .3

o. .51

p. 1.19

q. 1.02

6. Evaluated to satisfaction of instructor (40 points)

7. Evaluated to satisfaction of instructor (20 points)

8. Performance skills evaluated to satisfaction of instructor (160 points)

MICROMETER MEASURING TOOLS
UNIT IV

UNIT OBJECTIVE

After completion of this unit, the student should be able to read and use the common types of micrometer measuring tools. This knowledge will be evidenced by completion of assignment sheets, job sheets, and unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with micrometers to the correct definitions.
2. Name the major parts of micrometers.
3. Select the proper micrometer for a particular application.
4. State the rules for proper care and use of the micrometer.
5. Describe how parts of the micrometer work.
6. Read micrometer settings.
7. Demonstrate the ability to:
    a. Use the outside vernier micrometer.
    b. Use the depth micrometer.
    c. Use the inside micrometer.

MICROMETER MEASURING TOOLS
UNIT IV

SUGGESTED ACTIVITIES

I. Suggested activities for teacher:

   A. Provide student with objective sheets.

   B. Provide students with information and assignment sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information and assignment sheets.

   F. Demonstrate and discuss procedures outlined in job sheets.

   G. If possible, have advanced students pre-make parts and color code standard dowel pins to be used by students in this unit (Job Sheets #1, #2, and #3.)

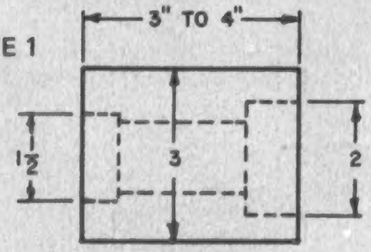
      1. Dowel pins with ends painted (two each)

         a. 9/16" Red
         b. 1/2" Blue
         c. 3/8" Green
         d. 5/16" Yellow
         e. 1/4" Brown

         (NOTE: Substitutions on sizes may be made.)

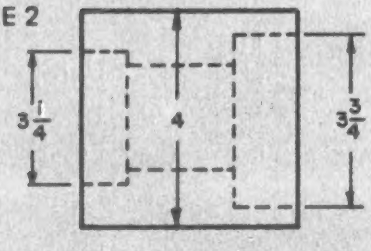
      2. Pipe - thick wall (two each)

FIGURE 1



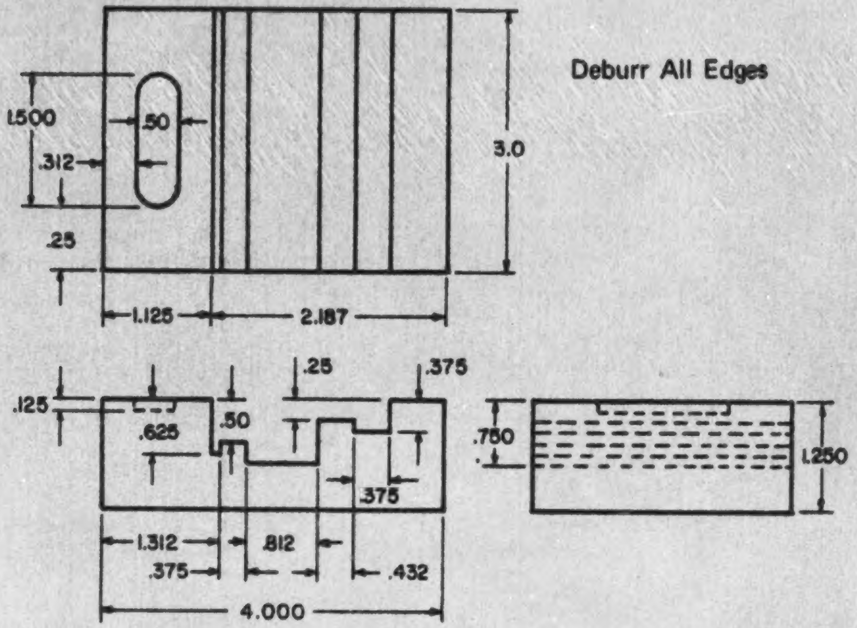
Face end smooth and bore 1"deep until smooth and round turn end for end. Face and bore other end slightly larger. Paint one end red (1) and the other blue (2).

FIGURE 2



Machine as per Figure 1 and paint ends yellow (3) and white (4).

3. Steel or aluminum block (two each)


1.500
.50
.312
.25
3.0
1.125
2.187
.125
.625
.50
.25
.375
.750
1.250
.375
1.312
.812
.375
.432
4.000

Deburr All Edges

(NOTE: When this part is made, dimensions that vary from sketch must be changed on job sheet and answer sheet.)

H. Stress trade techniques that vary from factory to factory.

Examples: Use of snap gauges, use of micrometer, use of go and no-go gauges

I. Point out that parts or parts of sets are not interchangeable from one tool to another.

J. Reinforce time efficiency.

K. Give test.

L. Reteach and retest if necessary.

II. Instructional materials:

A. Objective sheet

B. Information sheet

C. Transparency masters

1. TM 1–Parts of a Micrometer

2. TM 2–Reading the Micrometer

D. Assignment sheets

  1. Assignment Sheet #1–Name Major Parts of the Outside Vernier Micrometer

  2. Assignment Sheet #2--Select Proper Micrometer

  3. Assignment Sheet #3–Read Micrometer Settings

E. Answers to assignment sheets

F. Job sheets

  1. Job Sheet #1–Use the Outside Vernier Micrometer

  2. Job Sheet #2–Use the Depth Micrometer

  3. Job Sheet #3–Use the Inside Micrometer

G. Test

H. Answers to test

III. Unit references:

A. McCarthy, Willard J. and Smith, Robert E. *Machine Tool Technology*. Bloomington, IL: McKnight and McKnight, 1968.

B. Anderson, James and Tatro, Earl E. *Shop Theory*. 5th ed. Dallas: McGraw-Hill Book Company, 1968.

MICROMETER MEASURING TOOLS
UNIT IV

INFORMATION SHEET

I. Terms and definitions

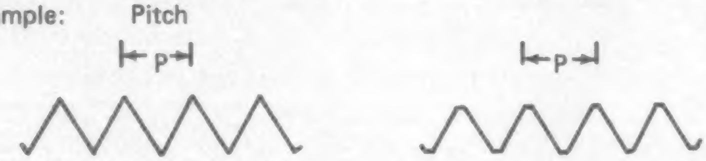
  A. Feel--Amount of tightness a person uses when measuring with a micrometer

  B. Range--Sizes that the micrometer can measure

  C. Standard--Tool used to check or calibrate a micrometer

  D. Pitch--Distance from one thread to the corresponding point of the next thread

  Example:



Sharp "V" National Form

  E. Scale--A unit of measurement

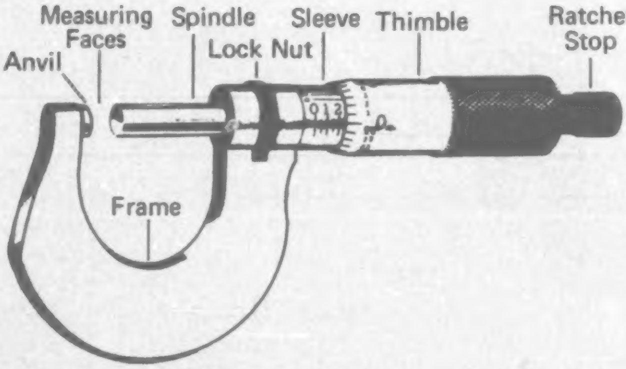
  F. Parallel--Two lines in the same plane and an equal distance from each other, never meeting no matter how far extended

  G. Tangent--Line that touches the circumference of a circle at one point only

  H. Calibrate--To measure or check against a standard

II. Major parts of micrometers (Assignment Sheet #1)

  A. Outside vernier micrometer



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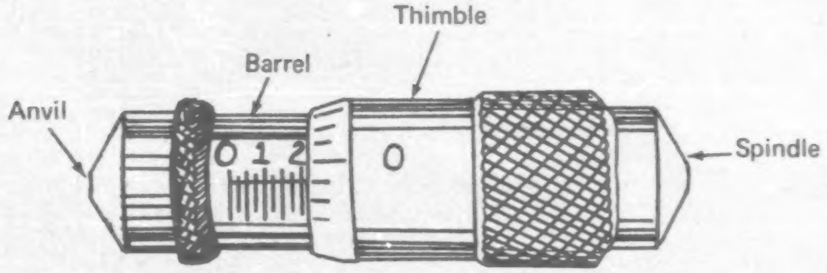
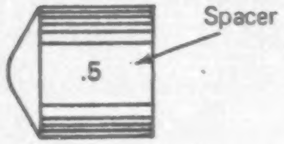
INFORMATION SHEET

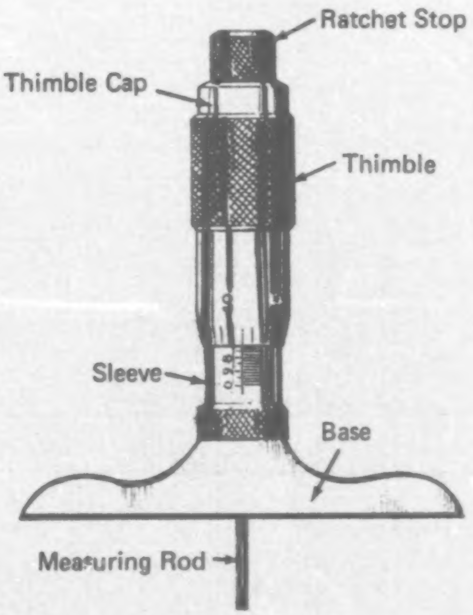
B. Inside micrometer

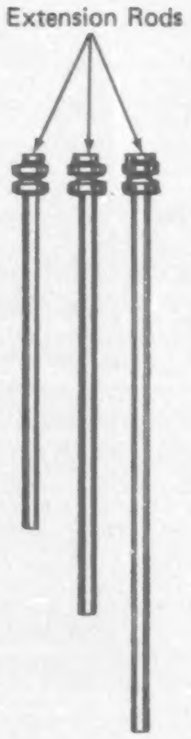

Thimble
Barrel
Anvil
0 1 2
0
Spindle



(NOTE: Spacer and extension rods are not interchangeable with parts of another depth or inside micrometer set.)

C. Depth micrometer


Ratchet Stop
Thimble Cap
Thimble
Sleeve
Base
Measuring Rod

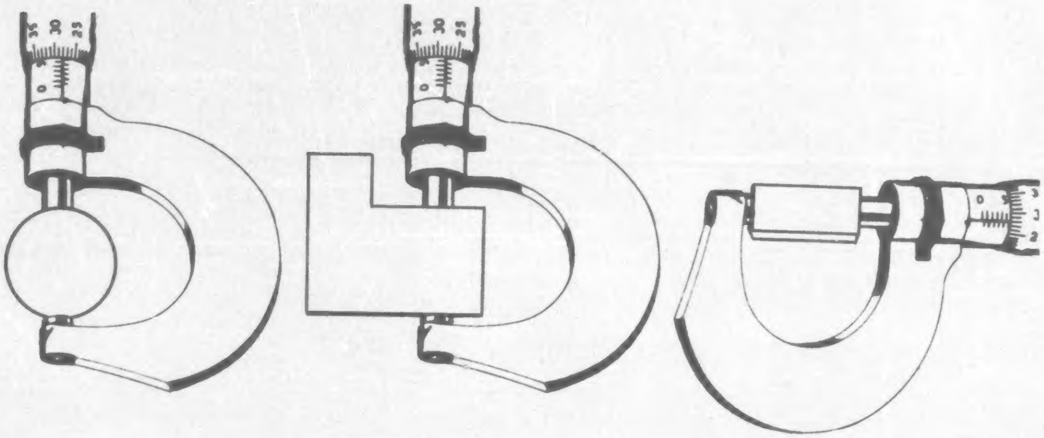

Extension Rods

INFORMATION SHEET

III. Micrometers and their applications (Assignment Sheet #2)

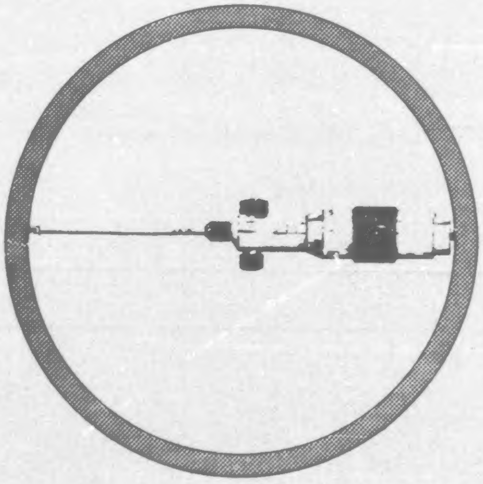
A. Outside vernier micrometer--Used to measure diameters, thickness, or length within the range of the micrometer

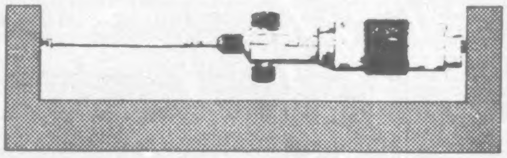
Examples:



B. Inside micrometer--Used to measure inside diameters or the distance between two inside points

Examples:



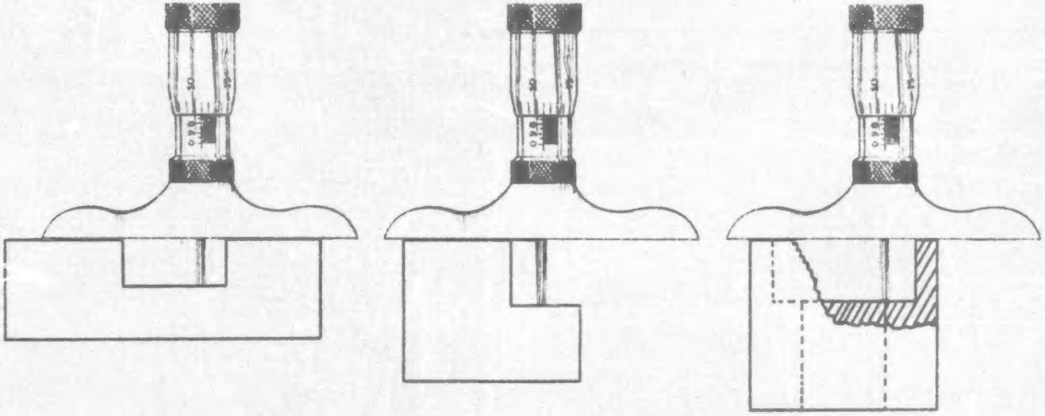


INFORMATION SHEET

C. Depth micrometer--Used to measure the depth of a hole, slot, or recess

(NOTE: These are the major uses of the depth micrometer; there are other uses for this tool.)

Examples:



IV. Rules for proper care and use of the micrometer

(NOTE: The greatest single assurance against excessive wear, breakage, and other damage to the micrometer is the careful user.)

A. Storage--Keep in place free of dirt, dust, and cutting fluids

B. Cleaning--Always wipe off with soft rag after using

C. Handling--Do not throw micrometer around; handle with care

D. Misuse--Do not use as a C clamp; overtightening will cause threads to be stretched and micrometer to lose its accuracy

E. Rapid movement--Do not run screw in or out by holding the thimble and swinging the frame; hold the frame and pull or push thimble in palm of hand

F. Holding--Hold the micrometer firmly when using, taking care not to drop it

G. Measuring--Hold the frame with left hand and rotate the thimble with the thumb and index finger of the right hand to reach the proper feel (amount of tightness)

H. Inspecting--Check the micrometer for accuracy before using

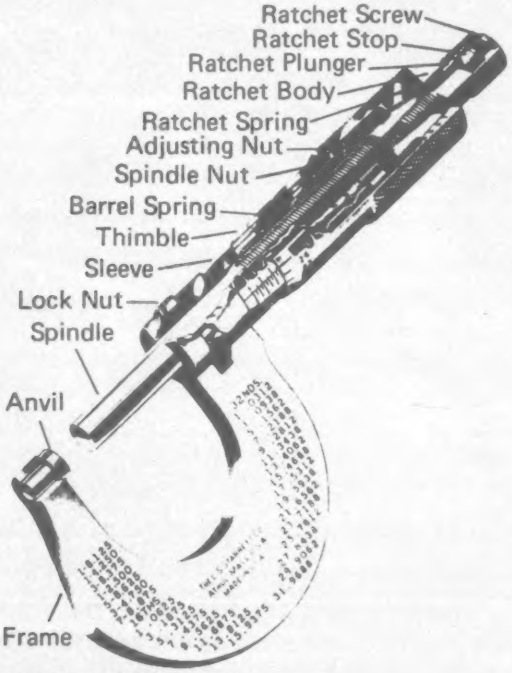
INFORMATION SHEET

V. How a micrometer works (Transparency 1)

A. Calibration of micrometer--Is determined by threaded portion of spindle which has 40 threads per inch

(NOTE: The spindle is threaded and connected to the thimble with a screw. The threaded portion of the spindle runs in a split nut that is secured to the frame.)

Example:


Ratchet Screw
Ratchet Stop
Ratchet Plunger
Ratchet Body
Ratchet Spring
Adjusting Nut
Spindle Nut
Barrel Spring
Thimble
Sleeve
Lock Nut
Spindle
Anvil
Frame

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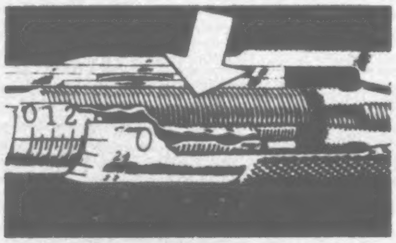
B. Barrel or sleeve--Shows revolutions of spindle moving lengthwise 1/40 of an inch or 25 thousandths of an inch (.025")

Examples:



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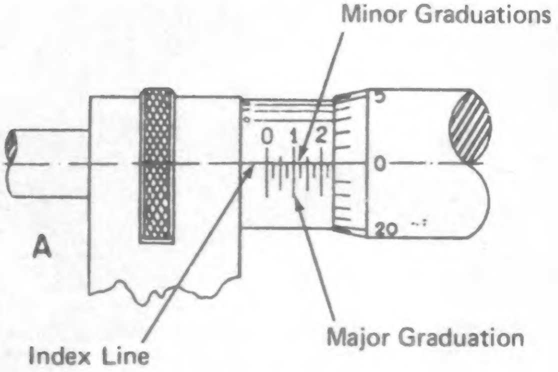
INFORMATION SHEET


Minor Graduations
0 1 2
5
0
20
A
Index Line
Major Graduation

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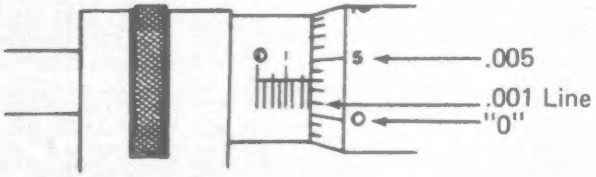
(NOTE: This becomes evident when a close examination is given to the barrel or sleeve of the micrometer; each minor graduation equals .025; .025 x 4 = .100, which is one major graduation; .100 x 10 = 1.000 inch.)

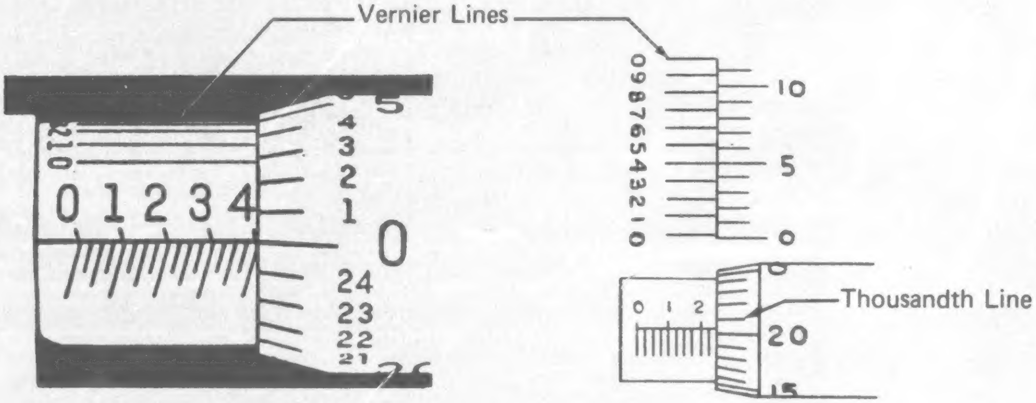
C. Thimble--Has a "0" line and is divided into 25 spaces around the circumference of the thimble. For easy counting it has major lines marked off in units of five. Each line on the thimble equals one thousandth of an inch (.001")

Example:


5
.005
.001 Line
0
"0"

INFORMATION SHEET

D. Vernier scale–These lines are parallel to the index line and located on the barrel. Vernier lines are numbered and will divide any thousandth line on the thimble into ten parts, each representing .0001 inch

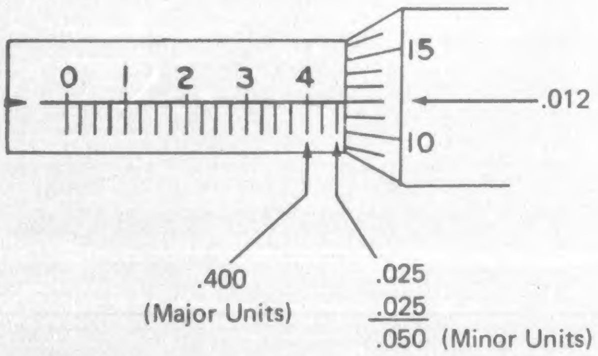

Vernier Lines
0 1 2 3 4
5
4
3
2
1
0
24
23
22
21
0 9 8 7 6 5 4 3 2 1 0
10
5
0
0 1 2
20
15
Thousandth Line

(NOTE: When the micrometer reading is exactly on thousandth line, the "0" line on the vernier is lined up with a number on the thimble.)

VI. How to read micrometer settings (Assignment Sheet #3)

A. Reading is obtained from scale on sleeve and thimble

Example:


0 1 2 3 4
15
10
.012
.400
(Major Units)
.025
.025
.050 (Minor Units)

Four major units, two minor units plus twelve thimble units; .400 + .025 + .025 + .012 = .462

The "0" mark on the thimble is greater than the .450 line by .012

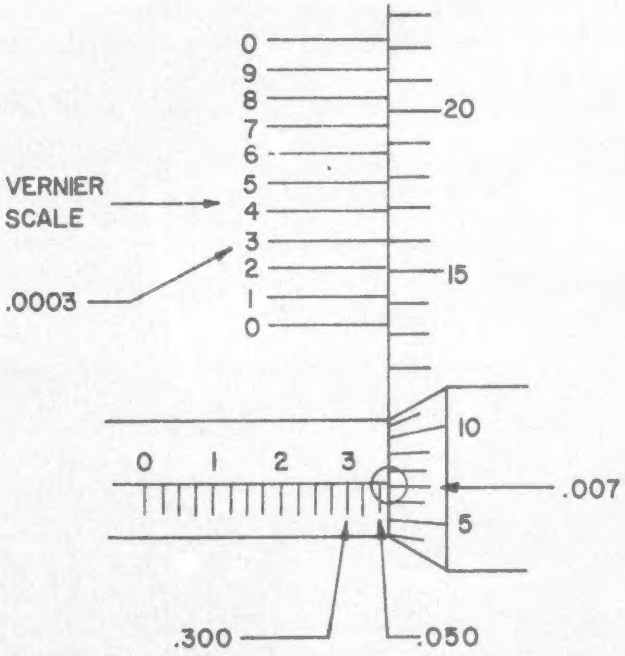
(NOTE: The reading just discussed could be that of a plain outside micrometer or an inside micrometer; however, most inside micrometers only have .500 travel; a spacer of .500 is used to cover the remainder of the inch.)

INFORMATION SHEET

B. A reading that is not on an even thousandth line must be carried to ten thousandths; this is accomplished by using the vernier scale. Look to see if one of the other lines on the vernier scale coincides with a line on the thimble. This number (on the vernier scale) indicates how many ten-thousandths of an inch should be added to the reading

(NOTE: When the index line and the lines on the thimble do not line up, the vernier measures the distance between the lines.)

Example:



In this example, the "0" or index line is .007 past .350, giving a reading of .357 plus. Since the index line and the thimble do not line up exactly, it is necessary to look up the vernier scale to see if any lines coincide. The "3" line coincides with a line on the thimble, so the reading should be increased by .0003 (three ten-thousandths)

Total reading .300 + .050 + .007 + .0003 = .3573

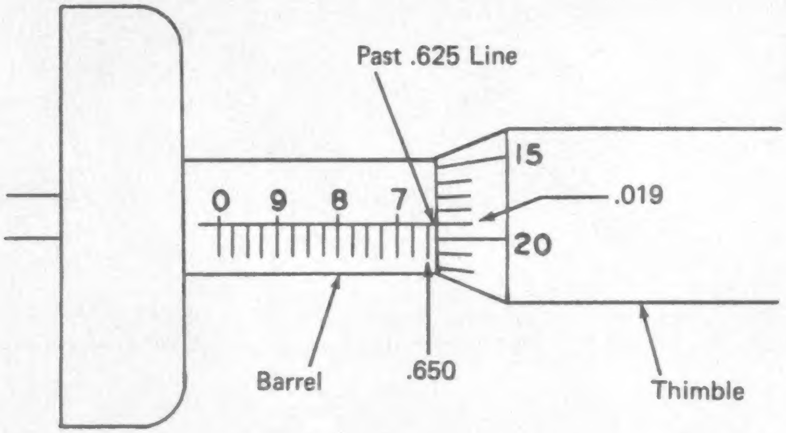
INFORMATION SHEET

C. Like the outside micrometer, the depth micrometer barrel has major units equaling .100, and each .100 line is divided into four equal parts of .025 each. The readings begin at 0 and go to 9, 8, 7, etc.

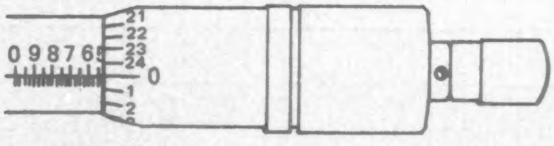
The thimble is numbered in reverse order from a standard micrometer

(NOTE: This measures the part of the micrometer covered by the thimble.)

Examples:

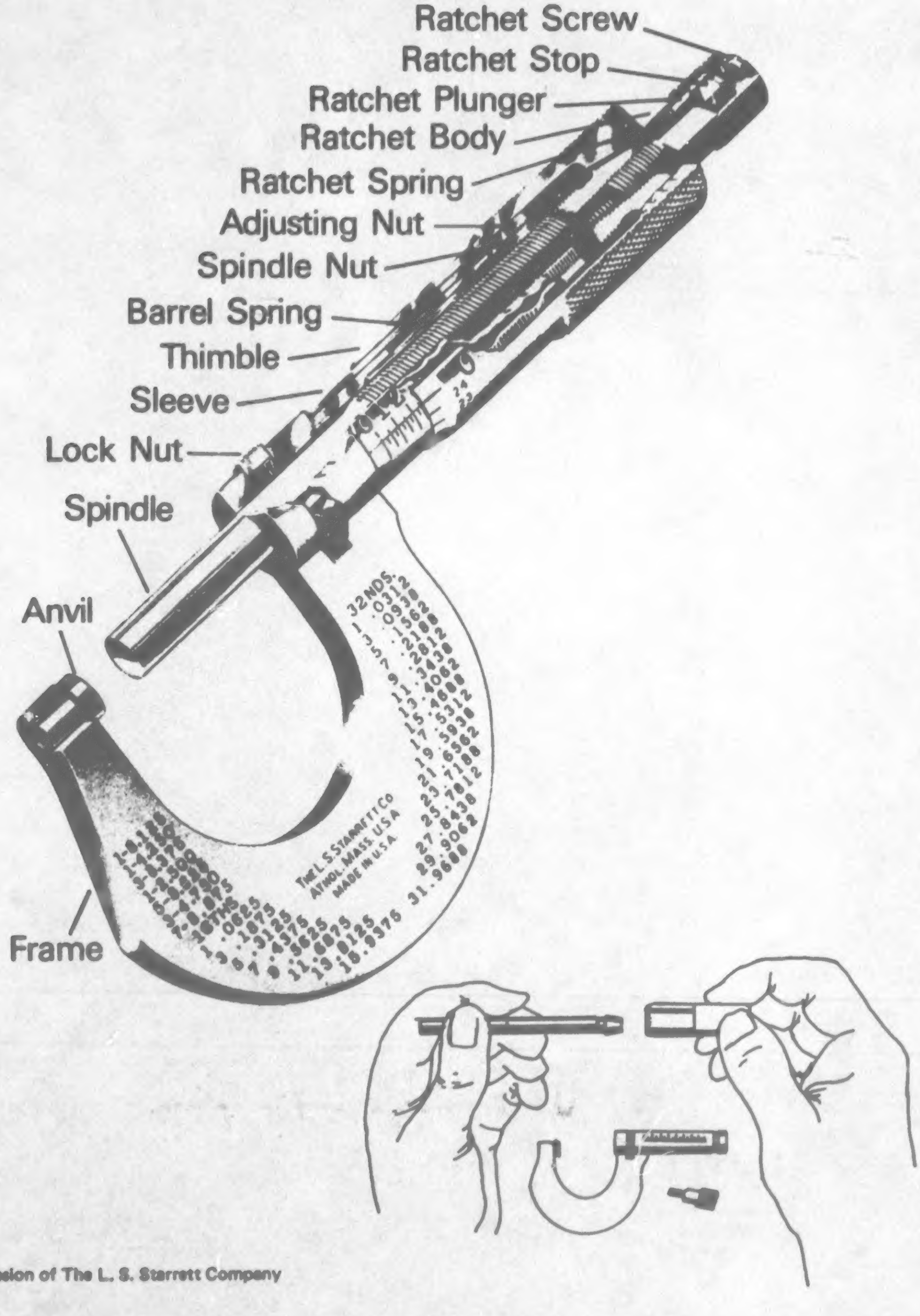

Past .625 Line
0
9
8
7
15
.019
20
Barrel
.650
Thimble

Total Reading .625
.019
.644


0 9 8 7 6 5
21
22
23
24
0
1
2

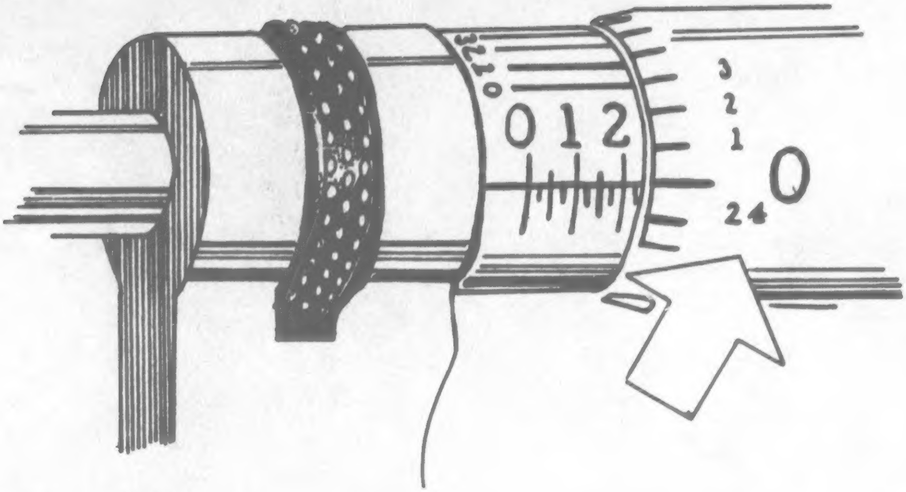
Reading = .525

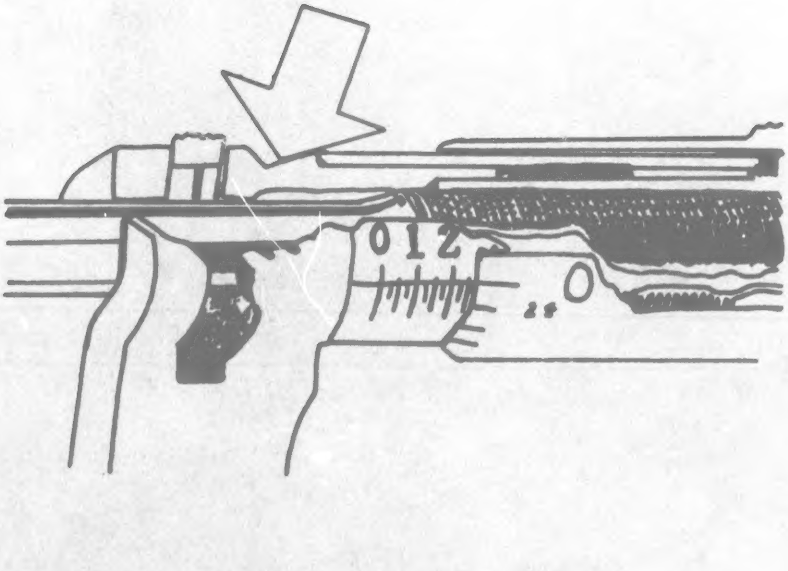
Parts of a Micrometer


Ratchet Screw
Ratchet Stop
Ratchet Plunger
Ratchet Body
Ratchet Spring
Adjusting Nut
Spindle Nut
Barrel Spring
Thimble
Sleeve
Lock Nut
Spindle
Anvil
Frame

Used with permission of The L. S. Starrett Company

Reading the Micrometer


3210
0 1 2
3
2
1
0
24



MICROMETER MEASURING TOOLS
UNIT IV

ASSIGNMENT SHEET #1–NAME MAJOR PARTS OF THE OUTSIDE VERNIER MICROMETER

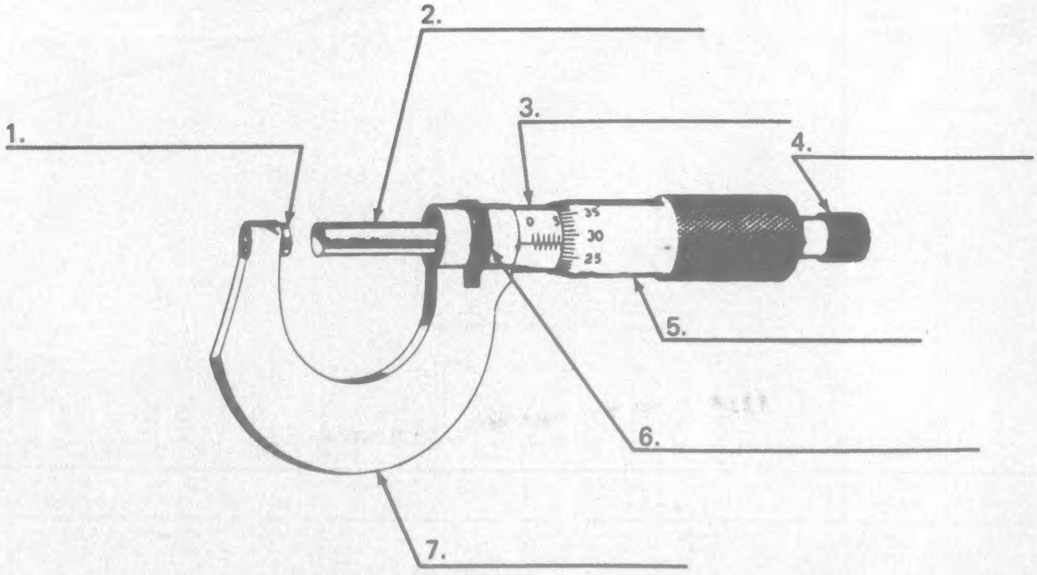
NAME____ SCORE_________________

Learning the major parts of the micrometer is necessary before you can use one correctly.

Practice naming parts of the micrometer shown below by writing the correct names in the blanks provided.

Frame
Anvil
Ratchet Stop
Spindle

Sleeve
Lock Nut
Thimble



MICROMETER MEASURING TOOLS
UNIT IV

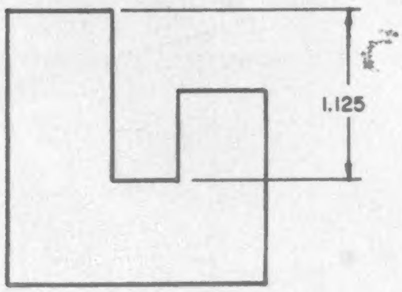
ASSIGNMENT SHEET #2–SELECT PROPER MICROMETER

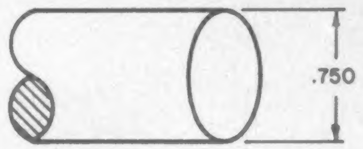
NAME ______________________________ SCORE ____________

Knowing which tool to use is as important as knowing how to read the micrometer.

Select the kind of micrometer that should be used in each situation by writing the correct numbers in the blanks.

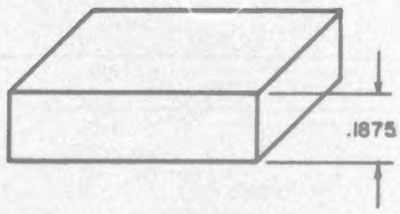
1. Outside vernier micrometer
2. Depth micrometer
3. Inside micrometer

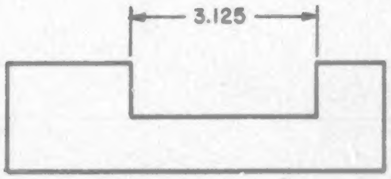




a. ______________________

b. ______________________

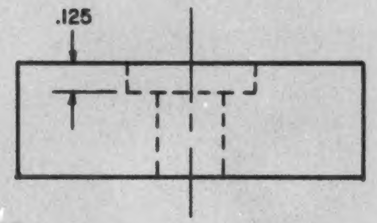


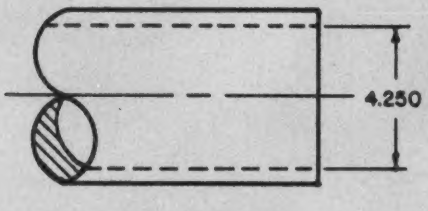


c. ______________________

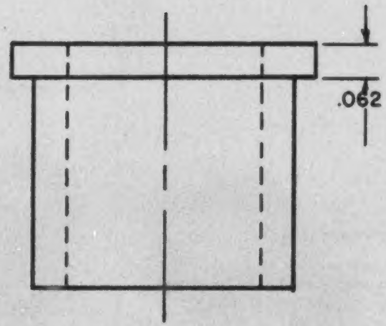
d. ______________________

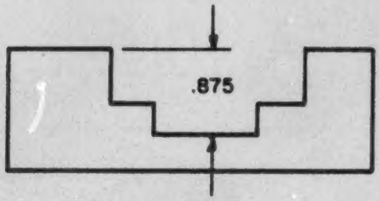
ASSIGNMENT SHEET #2





e. ____________________ f. ____________________





g. ____________________ h. ____________________

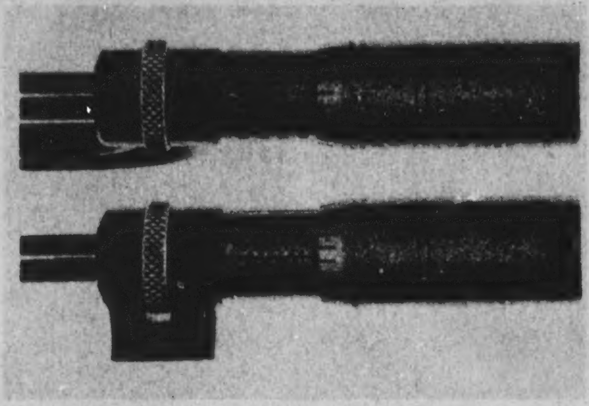
MICROMETER MEASURING TOOLS
UNIT IV

ASSIGNMENT SHEET #3--READ MICROMETER SETTINGS

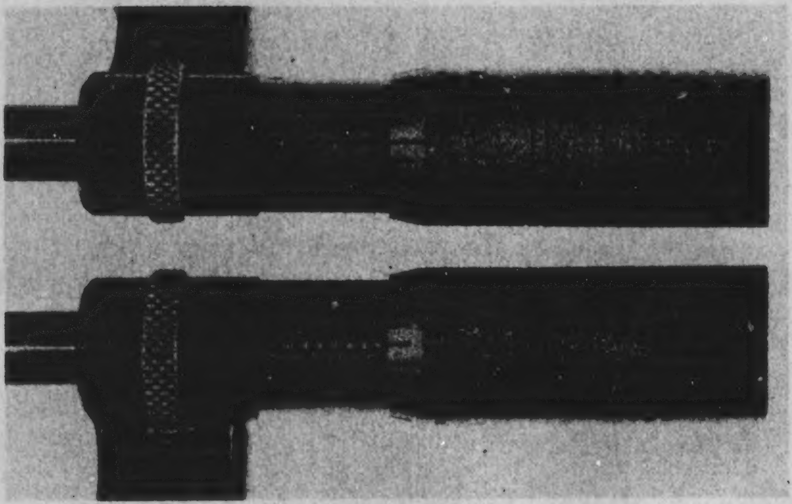
NAME______________________________ SCORE________________

It is important to learn how to read the micrometer quickly and accurately. Misreading the micrometer can cause a precision part to become a fishing weight and Brown's Machine Works is not in the business of making fishing weights.

1. Record the reading of each vernier micrometer setting pictured below in the spaces provided. Be sure to write the decimal point in the correct place.

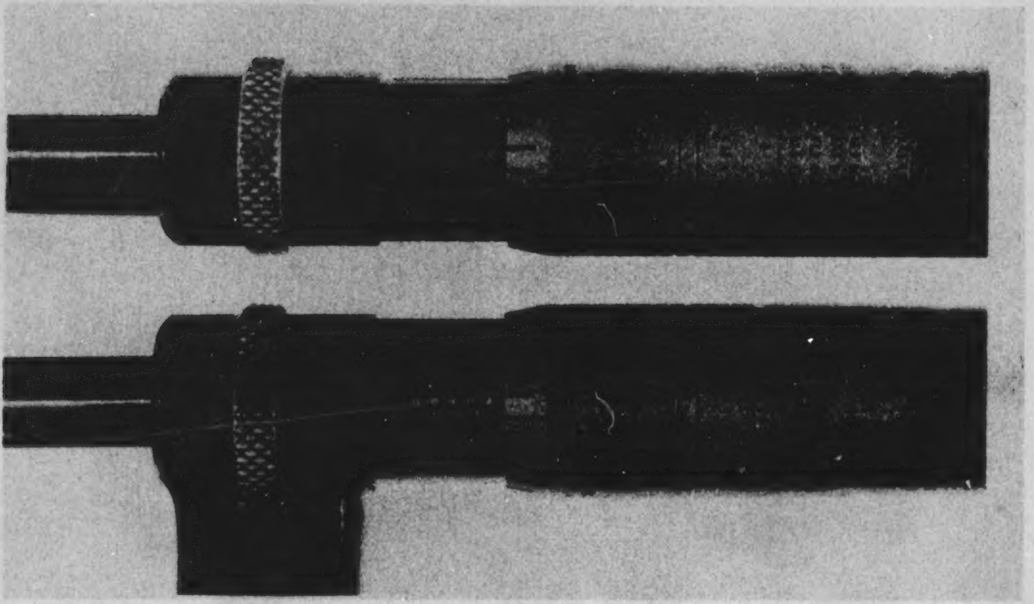


a. ____________________

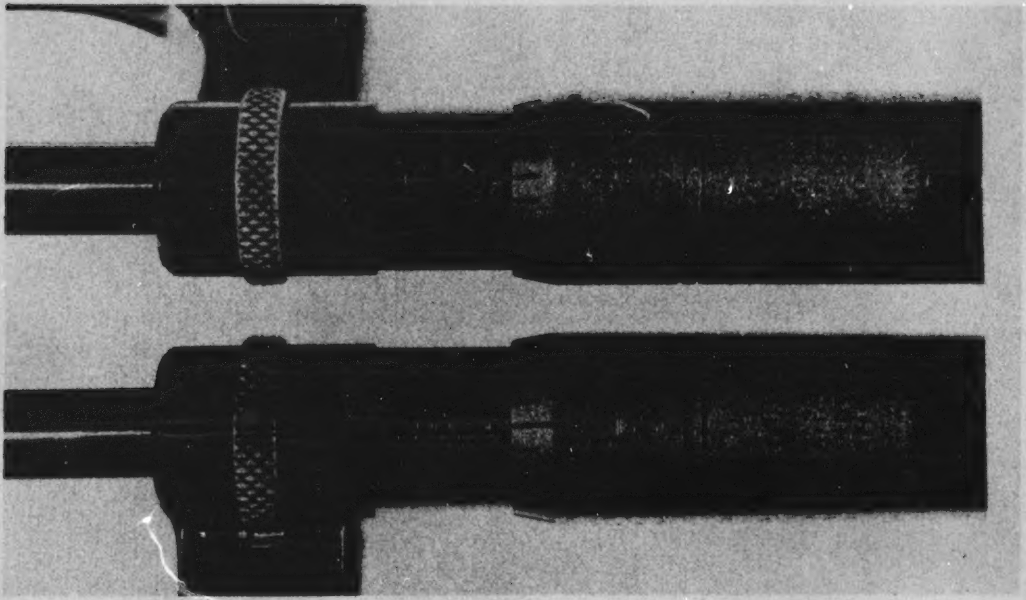


b.____________________

ASSIGNMENT SHEET #3



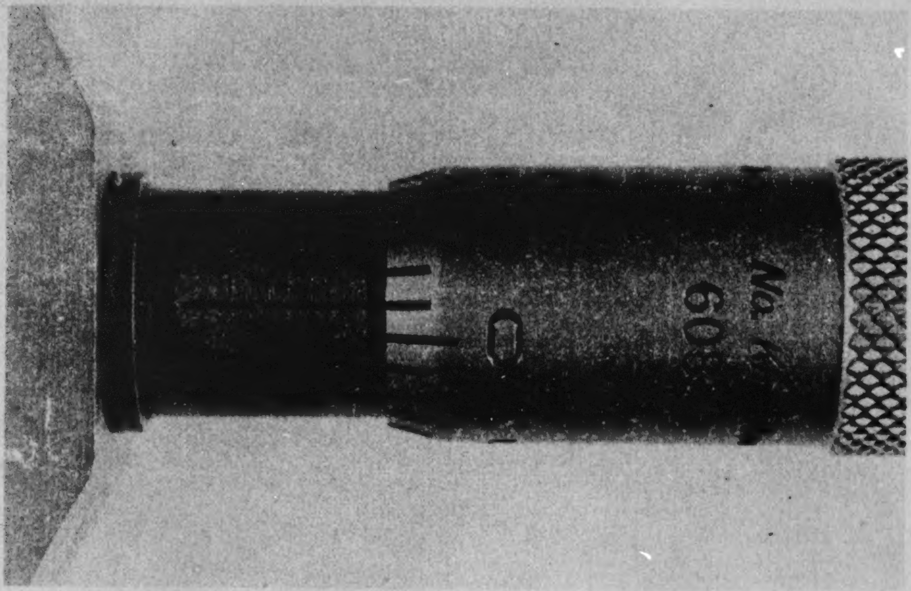
c.____________________________



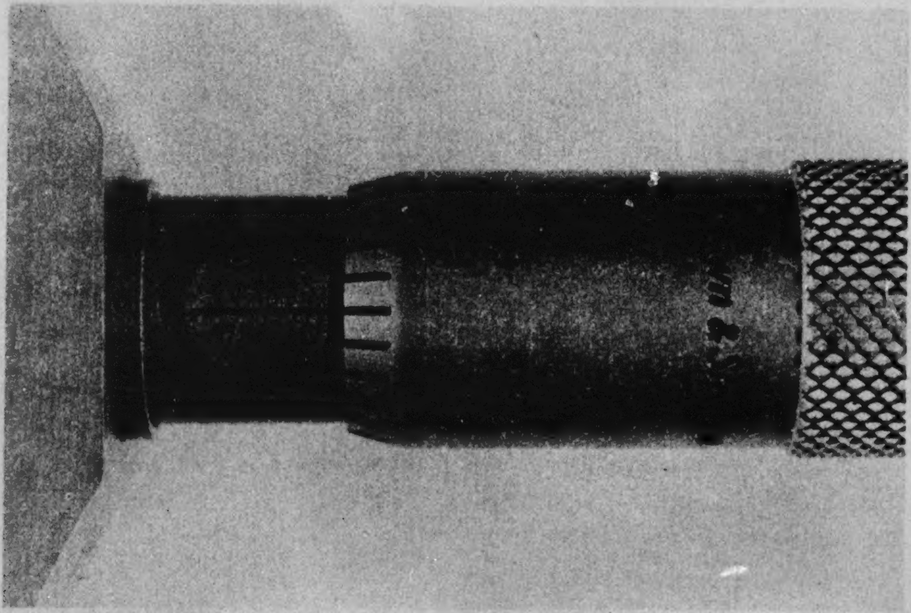
d.____________________________

ASSIGNMENT SHEET #3

2. Record the reading of each depth micrometer setting in the spaces provided.

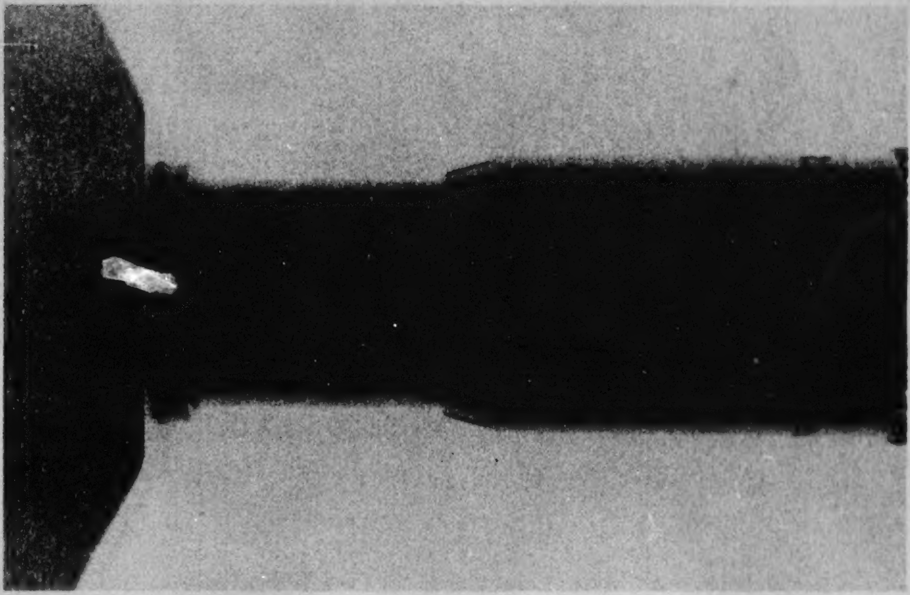


a. ______________________________

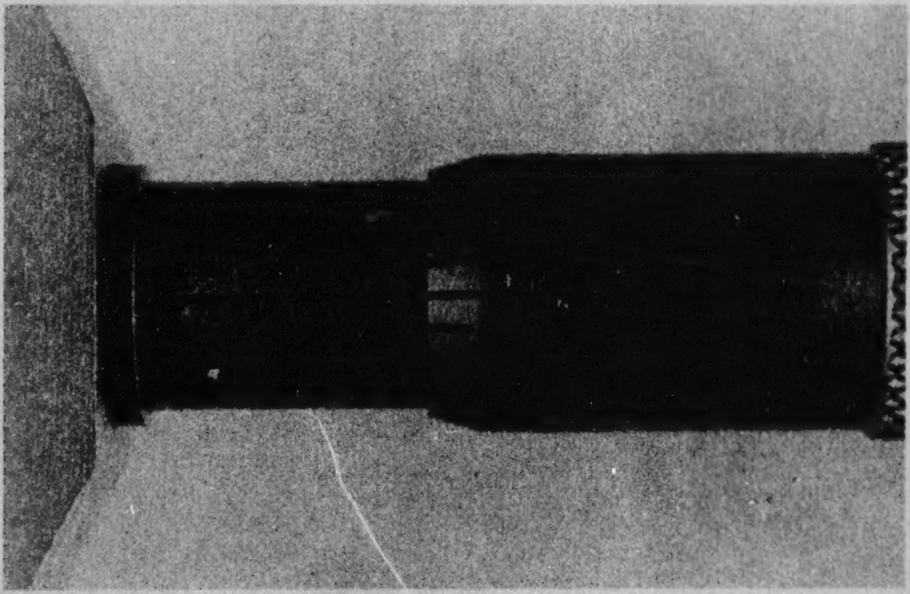


b. ______________________________

ASSIGNMENT SHEET #3



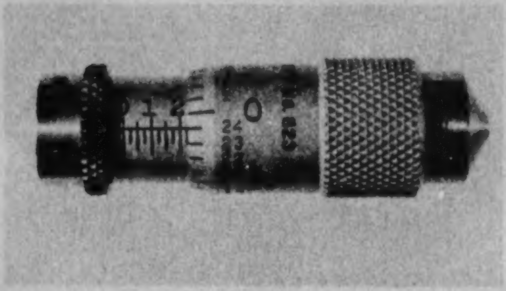
c. ____________________________

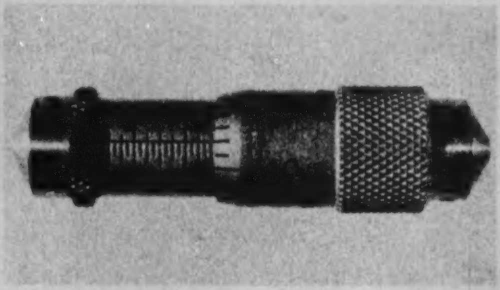


d. ____________________________

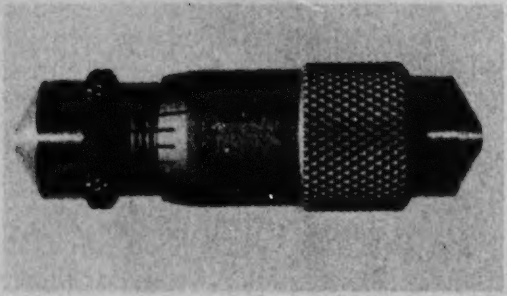
ASSIGNMENT SHEET #3

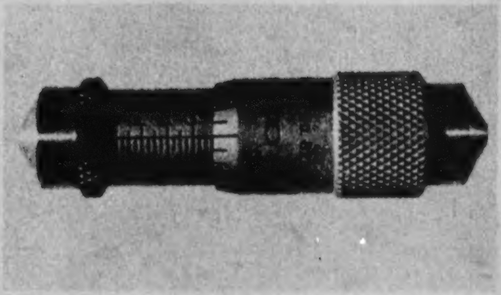
3. Record the reading of each inside micrometer in the spaces provided.





a. ______________________________ b. ______________________________





c. ______________________________ d. ______________________________

MICROMETER MEASURING TOOLS
UNIT IV

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

1. Anvil
2. Spindle
3. Sleeve
4. Ratchet stop
5. Thimble
6. Lock nut
7. Frame

Assignment Sheet #2

a. 2
b. 1
c. 1
d. 3
e. 2
f. 3
g. 1
h. 2

Assignment Sheet #3

1. a. .3633
   b. .3357
   c. .2454
   d. .2647
2. a. .724
   b. .817
   c. .712
   d. .655
3. a. 1.224
   b. 1.412
   c. 1.094
   d. 1.375

MICROMETER MEASURING TOOLS
UNIT IV

JOB SHEET #1–USE THE OUTSIDE VERNIER MICROMETER

I. Tools and equipment

   A. 0-1 vernier micrometer

   B. Dowel pins of assorted sizes with ends painted

      1. Red

      2. Blue

      3. Green

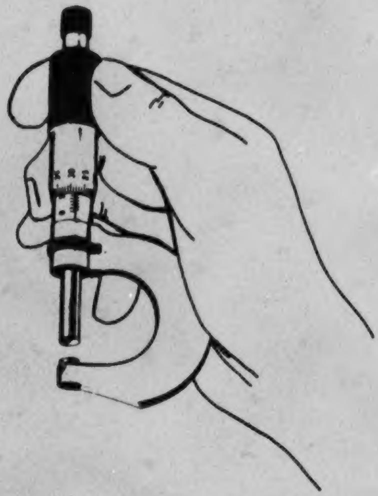
      4. Yellow

      5. Brown

II. Procedure

   A. Grasp micrometer in right hand so the little finger is through the frame and the thumb and index finger are on the thimble (Figure 1)

FIGURE 1



   B. Pick up the red dowel pin in left hand

   C. Adjust the micrometer by rotating the thimble clockwise or counterclockwise so you can insert the dowel pin between the anvil and the spindle

   D. Rotate one revolution larger or counterclockwise

JOB SHEET #1

E. Hold the dowel pin on the anvil and rotate the thimble clockwise until you feel a slight pressure or resistance to the thimble movement

F. Read the scale on the micrometer and record your reading according to dowel pin colors provided below

(NOTE: Make sure the decimal point is in the proper place.)

Example: Black .8125

Red ____________________

Blue ____________________

Green ____________________

Yellow ____________________

Brown ____________________

MICROMETER MEASURING TOOLS
UNIT IV

JOB SHEET #2–USE THE DEPTH MICROMETER

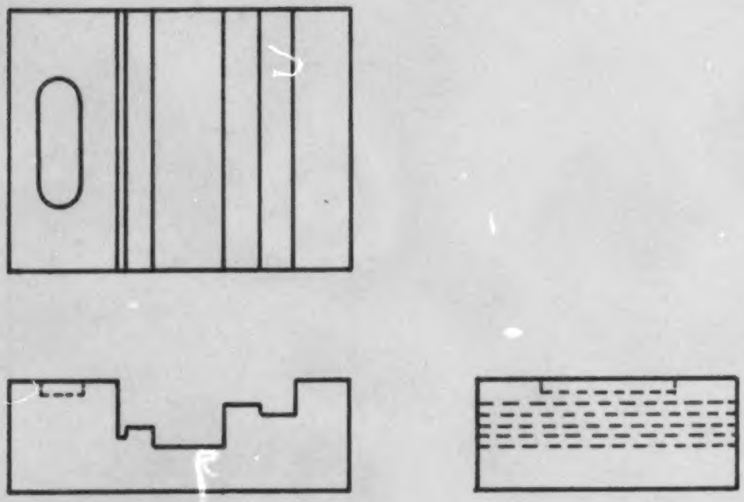
I. Tools and equipment

  A. Depth micrometer with extension rods

  B. Surface plate

  C. Steel or aluminum block pre-machined as per sketch (Figure 1)

FIGURE 1



II. Procedure

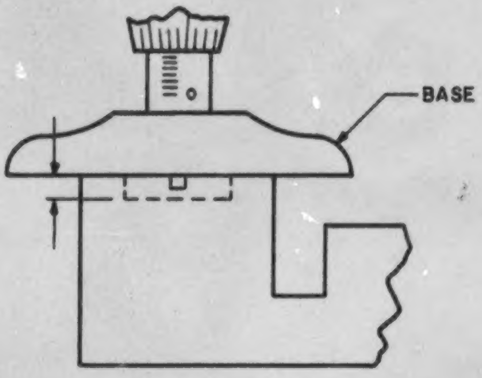
  A. Wipe surface plate with clean cloth to remove any dirt or dust

  B. Wipe off block and place on surface plate with slots up

JOB SHEET #2

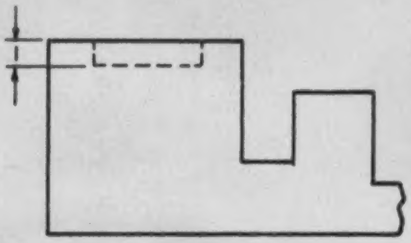
C. Pick up depth micrometer and place base on part so depth of milled slot can be recorded (Figure 2)

FIGURE 2



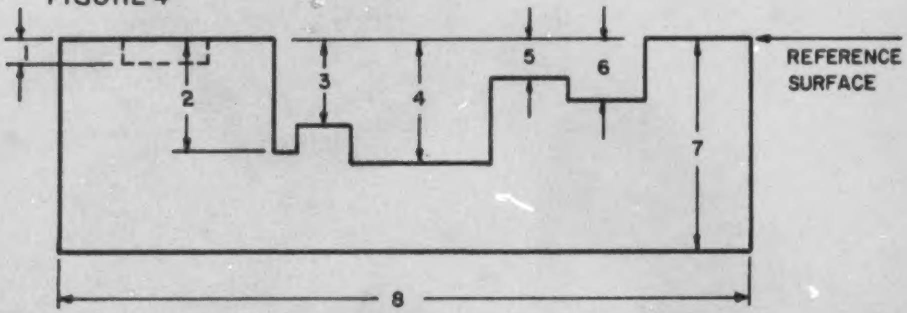
D. Hold the base down firmly with left hand and turn the thimble with the thumb and index finger of the right hand until you feel the spindle make contact with the bottom of the recess (Figure 3)

FIGURE 3



E. Use depth micrometer to measure and record readings (Figure 4)

FIGURE 4



1. ____________

2. ____________

3. ____________

4. ____________

5. ____________

6. ____________

7. ____________

8. ____________

MICROMETER MEASURING TOOLS
UNIT IV

JOB SHEET #3--USE THE INSIDE MICROMETER

I. Tools and equipment

   A. Inside micrometer with extension rods

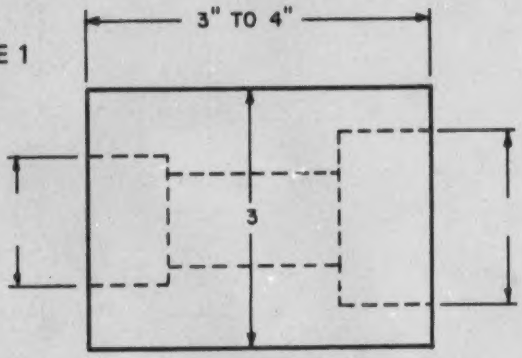
   B. Surface plate

   C. Steel rule

   D. Steel pipe pre-machined on inside diameter

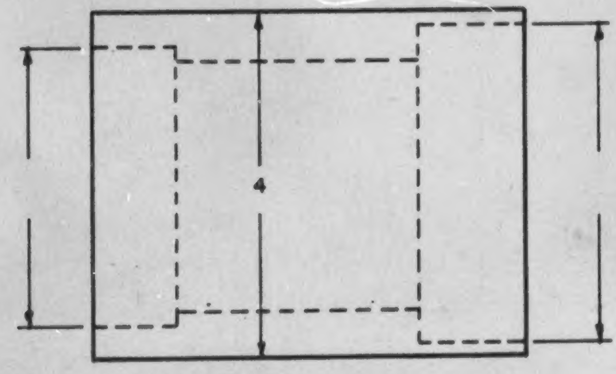
   E. 6" pipe (Figure 1)

FIGURE 1



   F. 4" pipe (Figure 2)

FIGURE 2



JOB SHEET #3

II. Procedure

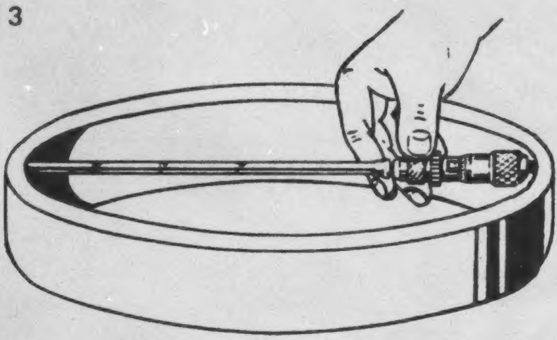
A. Place pipe on clean surface plate with red end up

B. Use steel rule to determine approximate diameter

C. Set up inside micrometer so that range is in that of the inside diameter

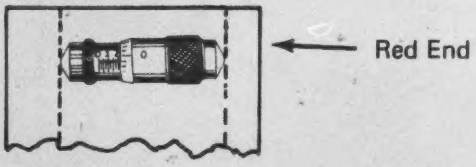
D. Insert micrometer in pipe and adjust out until spindle and anvil make contact with the walls of the pipe. Use both hands or extension handle if necessary (Figure 3)

FIGURE 3



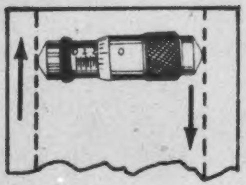
E. Keep ends of inside micrometer parallel to end of pipe and wiggle to make sure micrometer is at its maximum reading (Figure 4)

FIGURE 4



F. When you have the right feel, remove micrometer by pulling and pushing (Figure 5)

FIGURE 5



JOB SHEET #3

G. Record dimension by reading the micrometer and adding the length of micrometer plus extension rod

(NOTE: The steel rule will help you if you are in doubt as to approximate size.)

H. Turn part over and take measurement of blue end and record reading

I. Set that part to one side and measure yellow end. Record your reading

(NOTE: You must use a different extension rod.)

J. Turn and measure white end and record reading; repeat above procedures for other ends

Red ____________________

Blue ____________________

Yellow ____________________

White ____________________

MICROMETER MEASURING TOOLS
UNIT IV

TEST

NAME______________________________ SCORE______________

1. Match terms associated with micrometers to the correct definitions. Write the correct numbers in the blanks.

_____a. Sizes that the micrometer can measure

_____b. Tool used to check or calibrate a micrometer

_____c. Amount of tightness a person uses when measuring with a micrometer

_____d. Distance from one thread to the corresponding point of the next thread

_____e. A unit of measurement

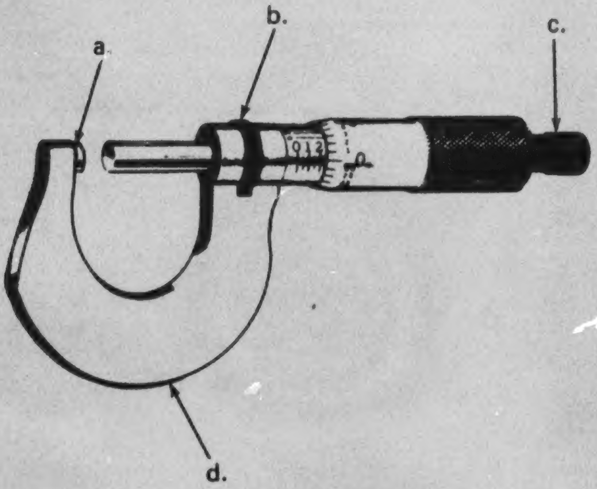
_____f. Two lines in the same plane and an equal distance from each other, never meeting no matter how far extended

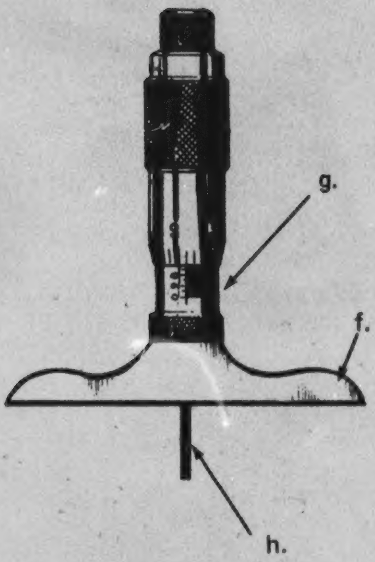
_____g. Line that touches the circumference of a circle at one point only

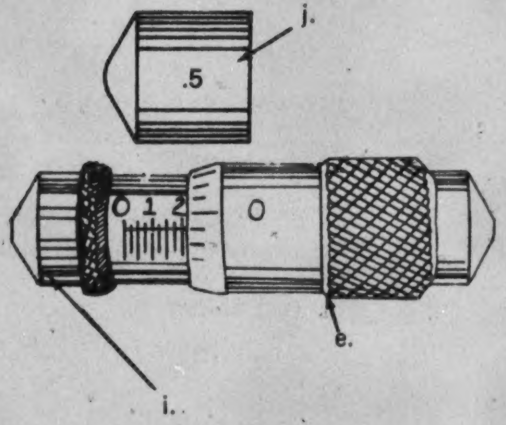
_____h. To measure or check against a standard

1. Pitch
2. Scale
3. Standard
4. Range
5. Feel
6. Tangent
7. Calibrate
8. Parallel

2. Name the major parts of the micrometers pictured below. Write the correct names in the blanks provided.







a. ____________________

b. ____________________

c. ____________________

d. ____________________

e. ____________________

f. ____________________

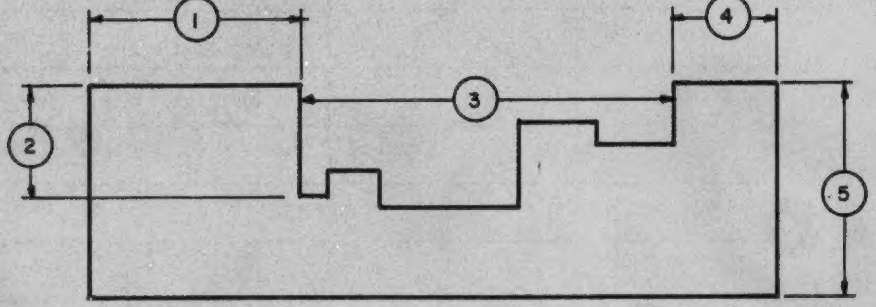
g. ____________________

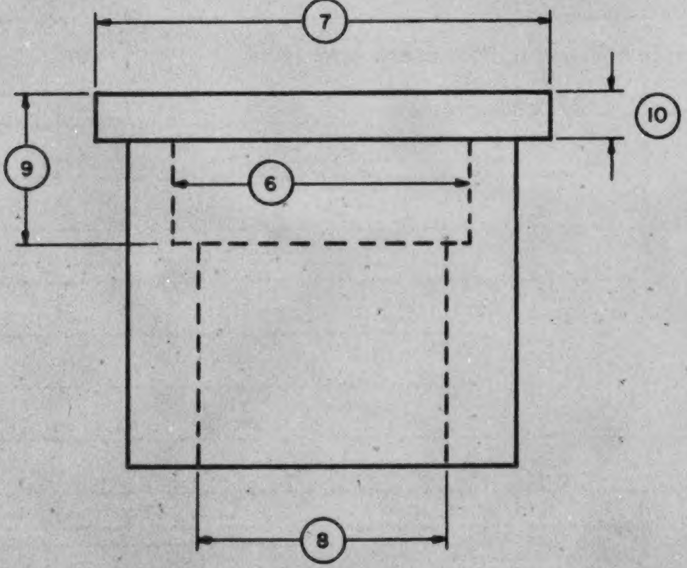
h. ____________________

i. ____________________

j. ____________________

3. Select the proper micrometer for each measurement shown below. Write a "D" for depth micrometer, an "I" for inside micrometer, and a "V" for vernier micrometer in the blanks provided.





__________ a.

__________ b.

__________ c.

__________ d.

__________ e.

__________ f.

__________ g.

__________ h.

__________ i.

__________ j.

4. State five rules for proper care and use of the micrometer.

a. ______________________________

____

b. ______________________________

____

c. ______________________________

____

d. ______________________________

____

e. ______________________________

____

5. Describe how parts of the micrometer work.

a. Calibration of micrometer-- ______________________________

____

____

____

b. Barrel or sleeve-- ______________________________

____

____

____

c. Thimble-- ______________________________

____

____

____

d. Vernier scale-- ______________________________

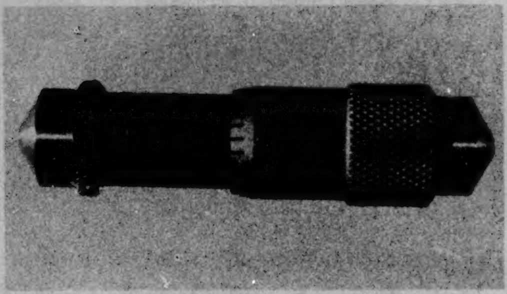
____

____

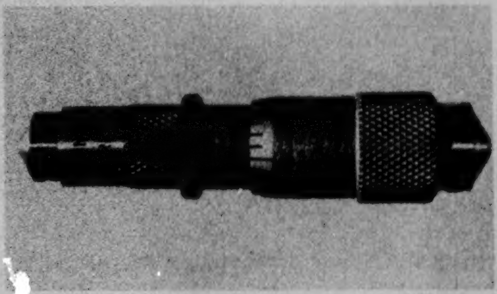
____

6. a. Read five inside micrometer settings and write your answers in the spaces provided.

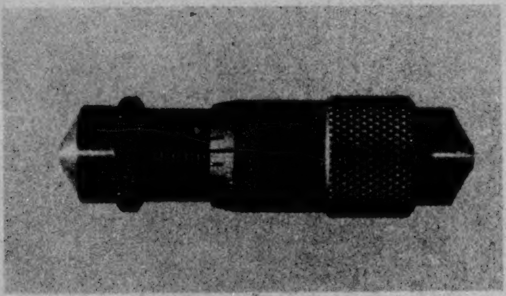
(NOTE: Be careful to put the decimal in the proper place.)



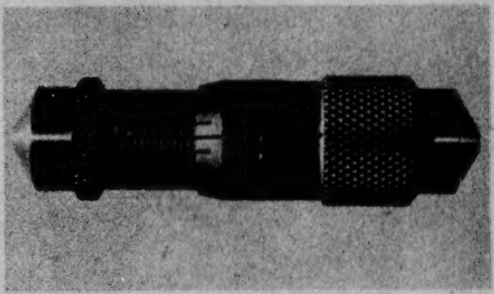
1) ______________________



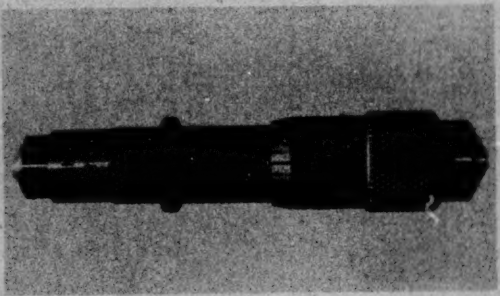
2) ______________________



3) ______________________



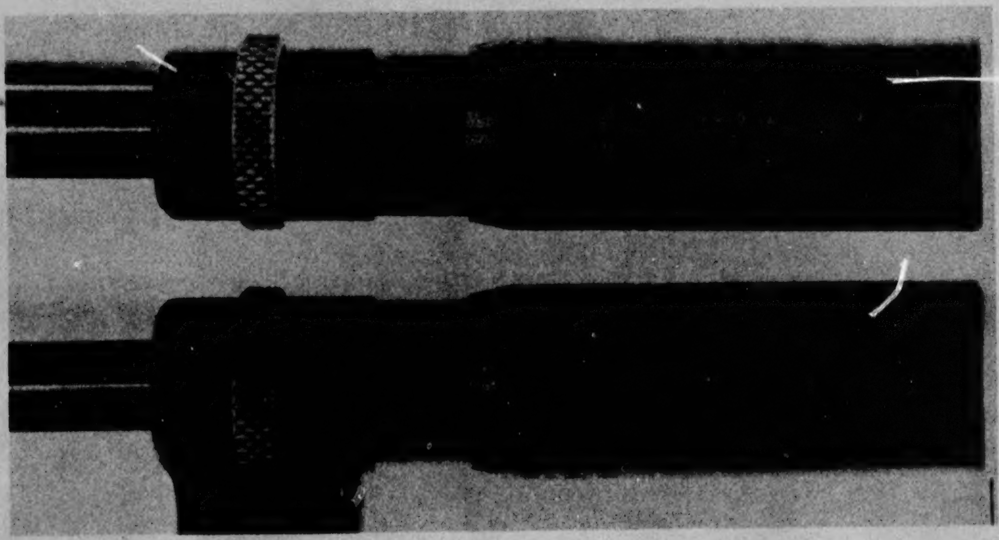
4) ______________________



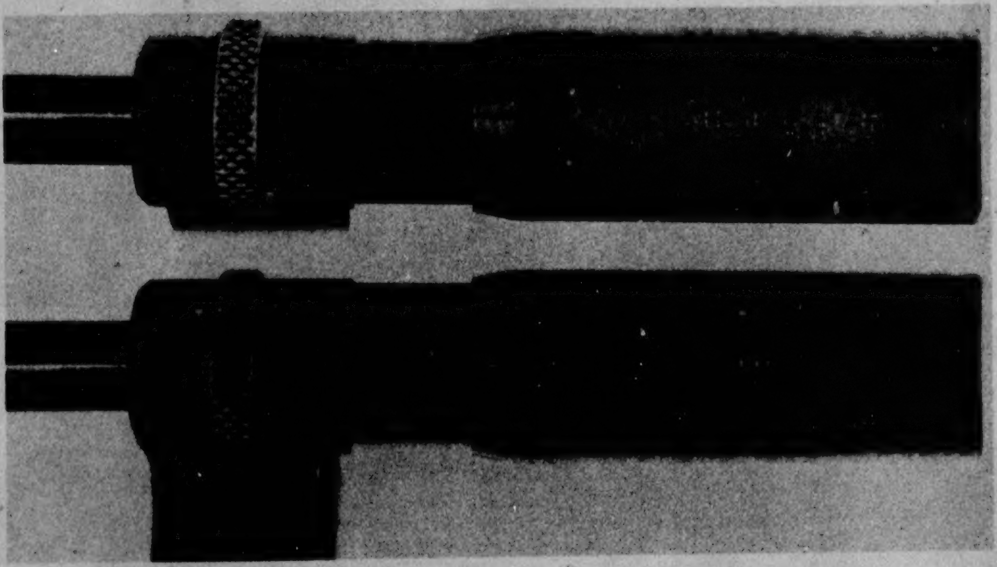
5) ______________________

b. Read ten vernier micrometer settings and write your answers in the spaces provided.

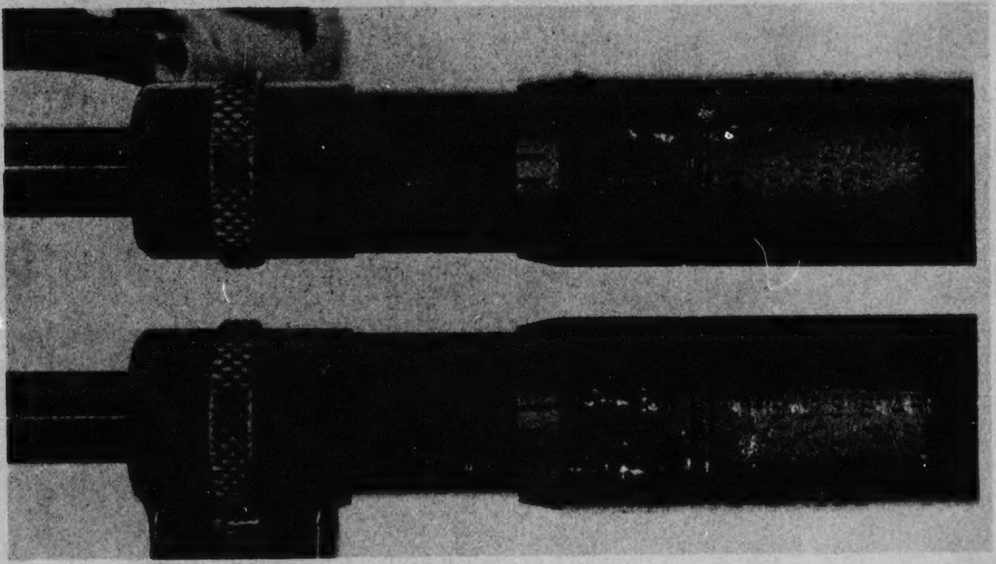
(CAUTION: Do not forget the decimal point.)



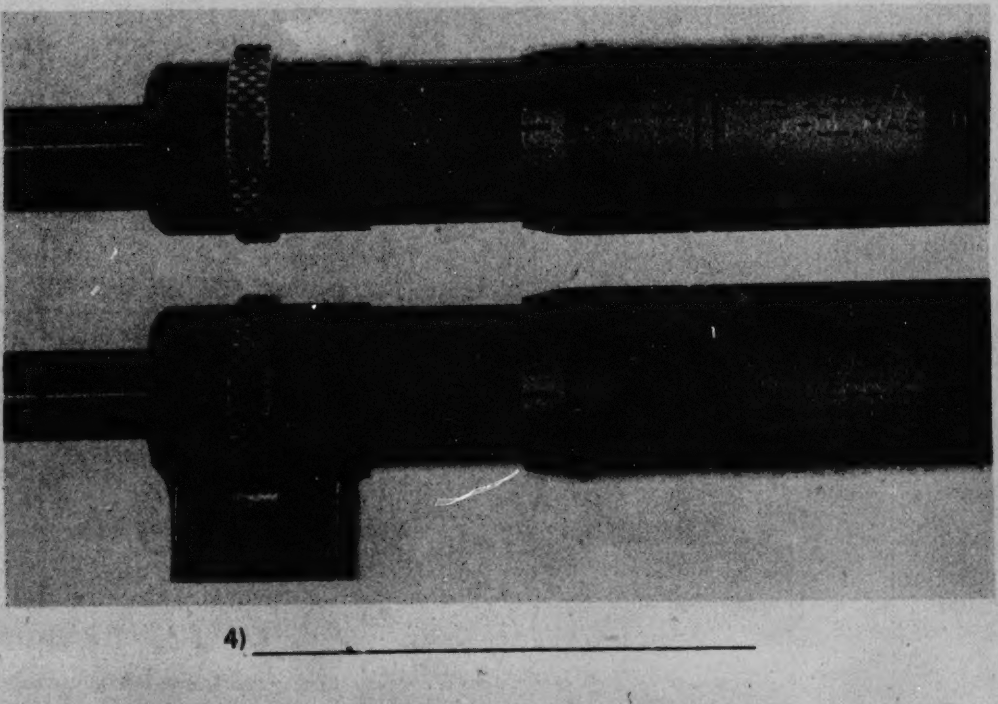
1) ______________________________



2) ______________________________

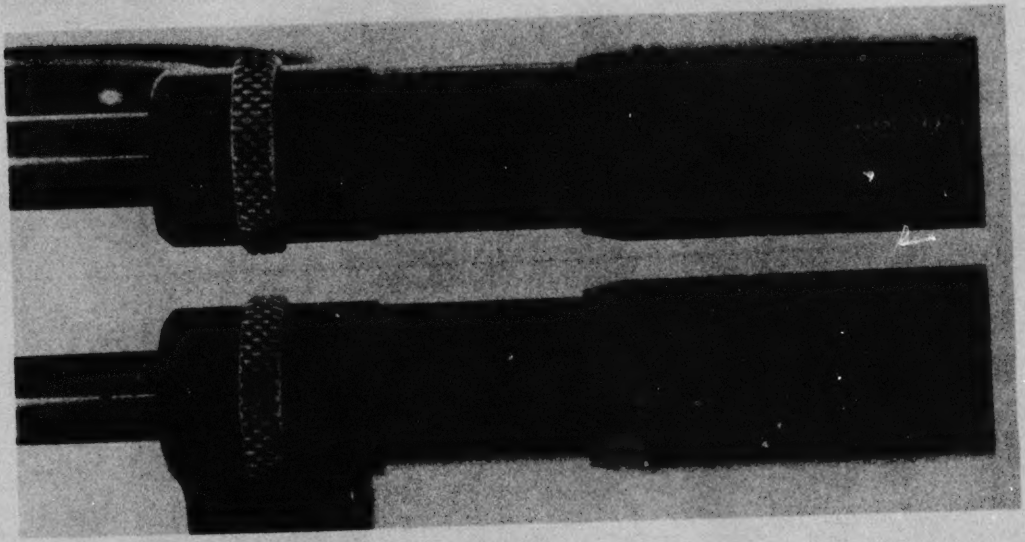


3) ______________________________

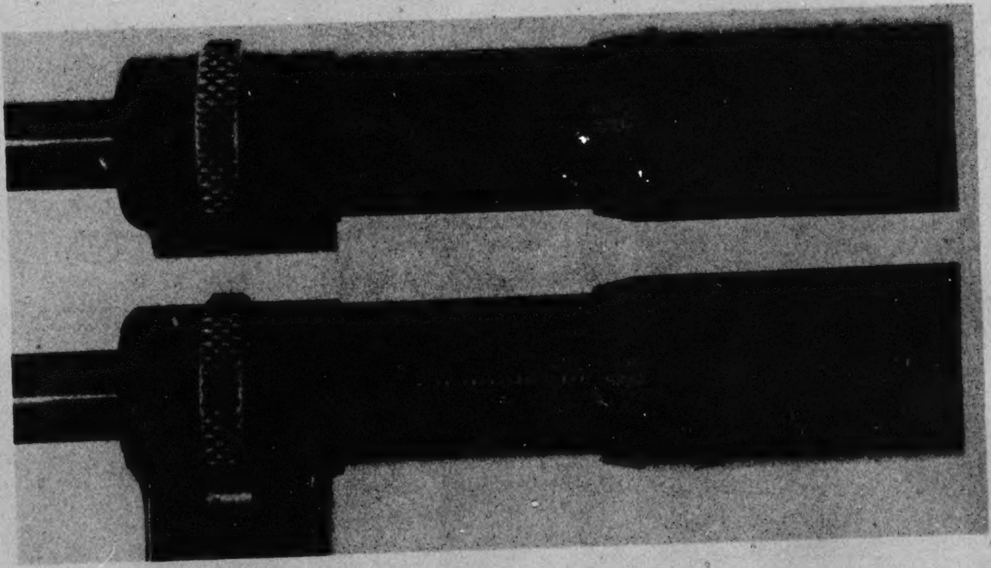


4) ______________________________

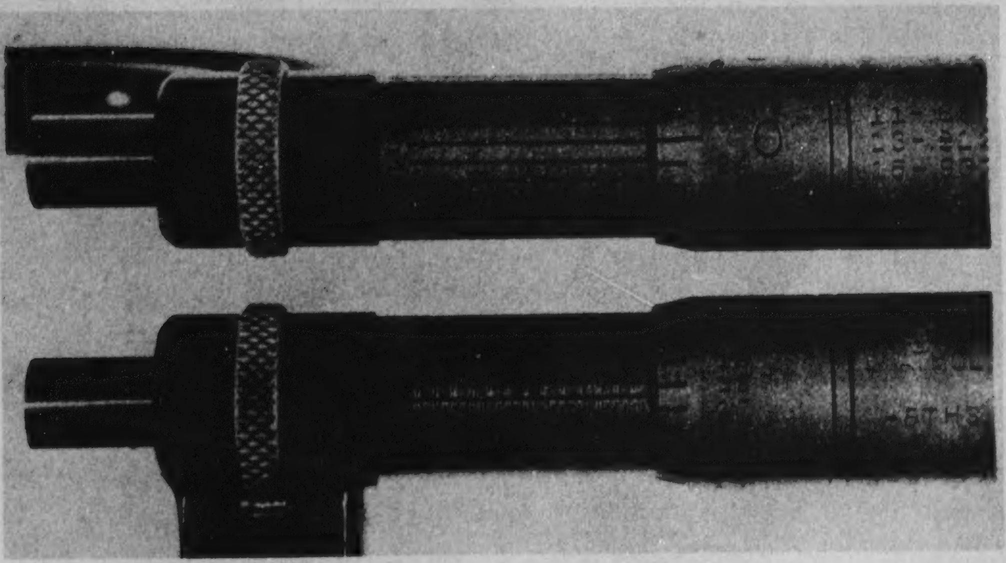
274-B



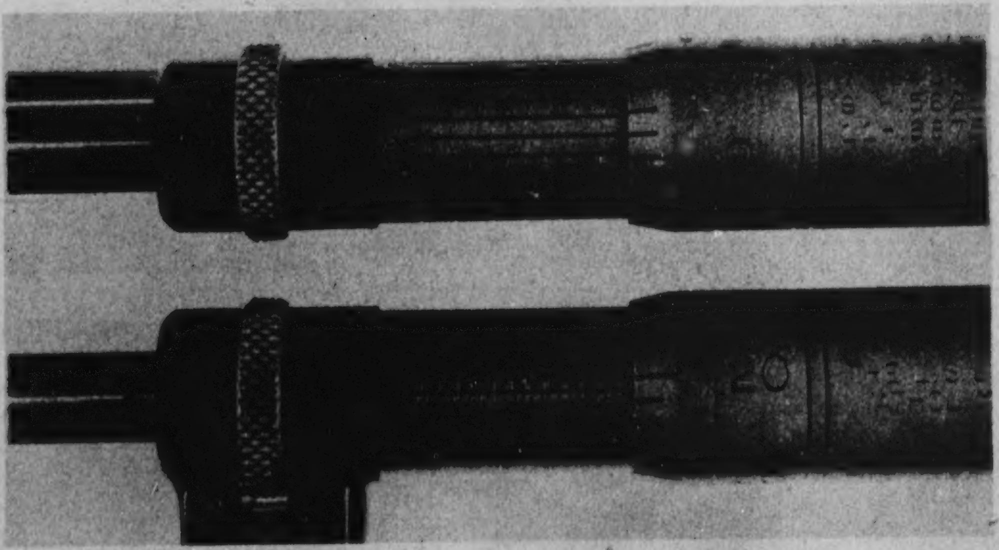
5) ____________________________________



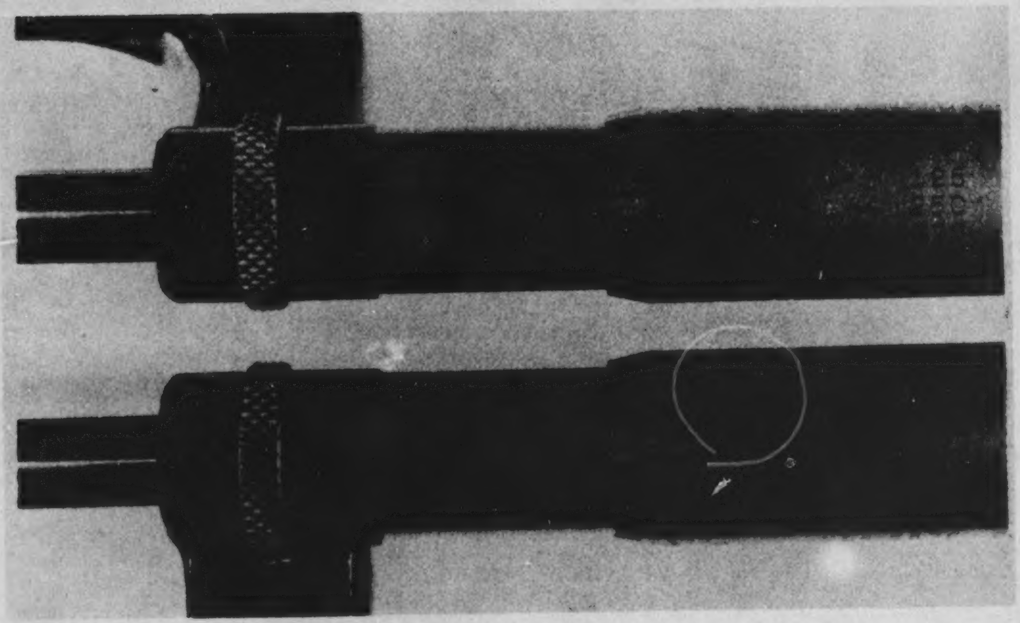
6) ____________________________________



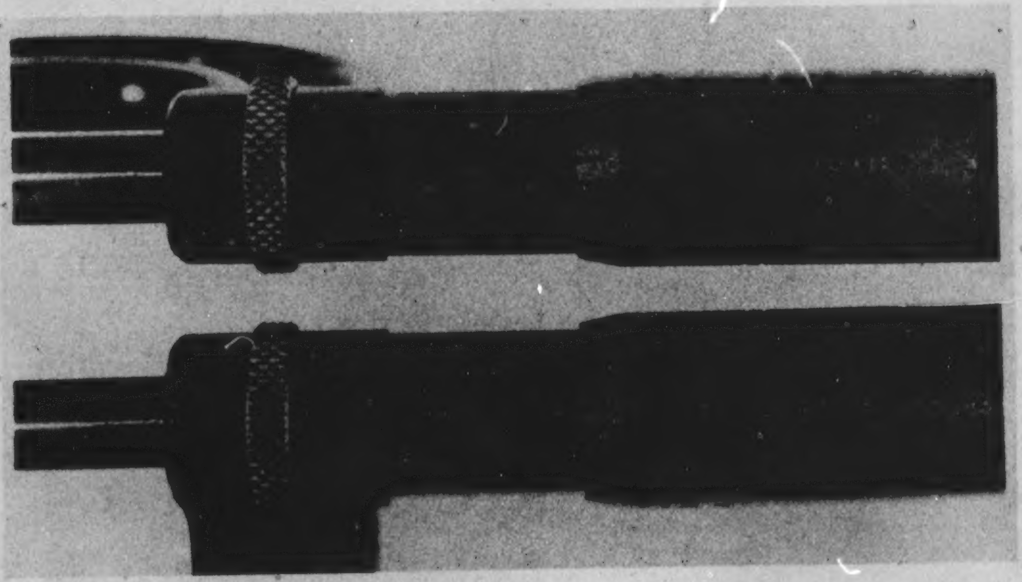
7) ______________________________



8) ______________________________

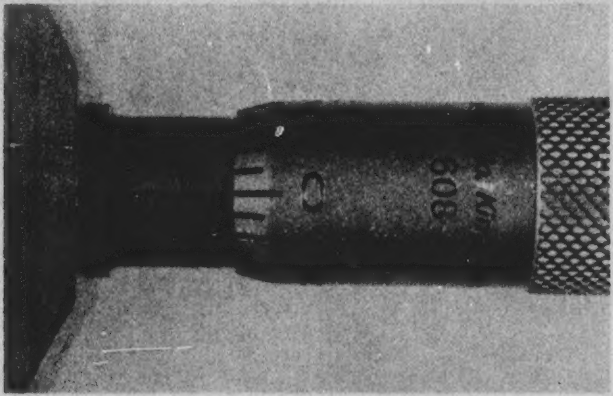


9) ______________________________

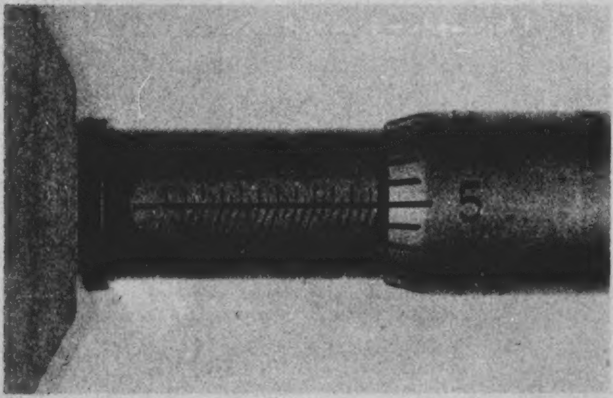


10) ______________________________

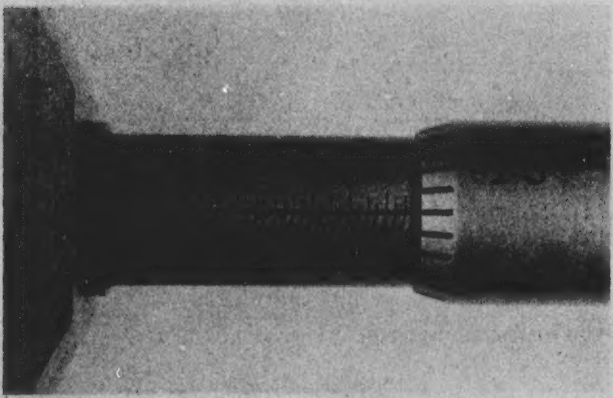
c. Read five depth micrometer settings and write your answers in the spaces provided.



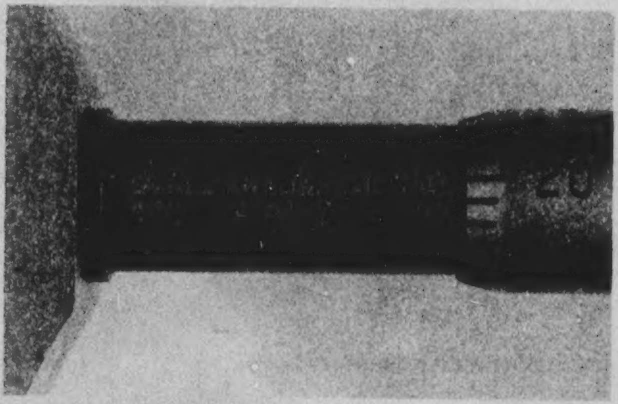
1) ______________________________



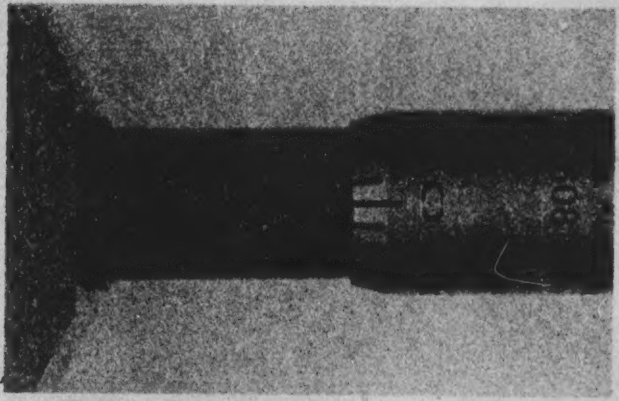
2) ______________________________



3) ______________________________



4) ______________________________



5) ______________________________

7. Demonstrate the ability to:

   a. Use the outside vernier micrometer.

   b. Use the depth micrometer.

   c. Use the inside micrometer.

   (NOTE: If the above activities have not been finished before the test, ask your instructor when they should be completed.)

MICROMETER MEASURING TOOLS
UNIT IV

ANSWERS TO TEST

(NOTE: The point system designated in parentheses is intended to be a guideline and should be adapted as needed. The point total is 300.)

1. (16 points)

   a. 4

   b. 3

   c. 5

   d. 1

   e. 2

   f. 8

   g. 6

   h. 7

2. (20 points)

   a. Ratchet stop

   b. Lock nut

   c. Anvil

   d. Frame

   e. Thimble

   f. Base

   g. Sleeve

   h. Spindle

   i. Barrel

   j. Spacer

3. (20 points)

   a. V

   b. D

   c. I

   d. V

   e. D

   f. I

   g. V

   h. I

   i. D

   j. V

4. (20 points)

Any five of the following:

a. Storage--Keep in place free of dirt, dust, and cutting fluids

b. Cleaning--Always wipe off with soft rag after using

c. Handling--Do not throw micrometer around; handle with care

d. Misuse--Do not use as a C clamp; overtightening will cause threads to be stretched and micrometer to lose its accuracy

e. Rapid movement--Do not run screw in or out by holding the thimble and swinging the frame; hold the frame and pull or push thimble in palm of hand

f. Holding--Hold the micrometer firmly when using, taking care not to drop it

g. Measuring--Hold the frame with left hand and rotate the thimble with the thumb and index finger of the right hand to reach the proper feel (amount of tightness)

h. Inspecting--Check the micrometer for accuracy before using

5. (25 points)

Description should include the following points:

a. Calibration of micrometer--Is determined by threaded portion of spindle which has 40 threads per inch

b. Barrel or sleeve--Shows revolutions of spindle moving lengthwise 1/40 of an inch or 25 thousandths of an inch (.025")

c. Thimble--Has a "O" line and is divided into 25 spaces around the circumference of the thimble. For easy counting it has major lines marked off in units of five. Each line on the thimble equals one thousandth of an inch (.001")

d. Vernier scale--These lines are parallel to the index line and located on the barrel. Vernier lines are numbered and will divide any thousandth line on the thimble into ten parts, each representing .0001 inch

6. (100 points)

a. 1) 1.478
2) 1.661
3) 1.230
4) 1.315
5) 1.895

b. 1) .1504
2) .2161
3) .3446
4) .3124
5) .4615
6) .6250
7) .6675
8) .5944
9) .5307
10) .4255

c. 1) .825

2) .405

3) .312

4) .196

5) .500

7. (99 points)

Performance skills evaluated to satisfaction of instructor

(NOTE: Performance should be trade acceptable. All readings should be accurate to at least three significant decimal places.)

VERNIER MEASURING TOOLS
UNIT V

UNIT OBJECTIVE

After completion of this unit, the student should be able to read and use the common types of vernier measuring tools. This knowledge will be shown by completion of assignment sheets, job sheets, and unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with vernier measuring tools to the correct definitions.
2. Label basic types of vernier measuring tools.
3. Identify the major parts of vernier measuring tools.
4. Describe how vernier measuring tools work.
5. Select the correct vernier measuring tool.
6. State the rules for proper care of vernier measuring tools.
7. Read vernier measuring tools.
8. Demonstrate the ability to:
    a. Use vernier caliper to take inside, outside, and depth measurements.
    b. Use the depth vernier.
    c. Use the vernier height gage for layout and inspection.
    d. Use the universal bevel protractor to measure angles.

VERNIER MEASURING TOOLS
UNIT V

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

   A. Provide student with objective sheet.

   B. Provide student with information, assignment, and job sheets.

   C. Discuss unit and specific objectives.

   D. Discuss information and assignment sheets.

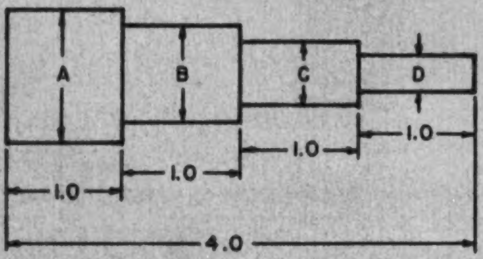
   E. Demonstrate and discuss procedures outlined in job sheets.

   F. If possible, have advanced student pre-make parts to be used by students in this unit for Job Sheets #1-#4.

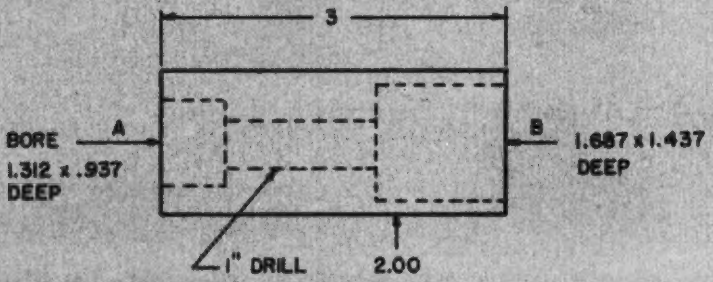
   (NOTE: If student misses dimension, change answer to correspond with it.)

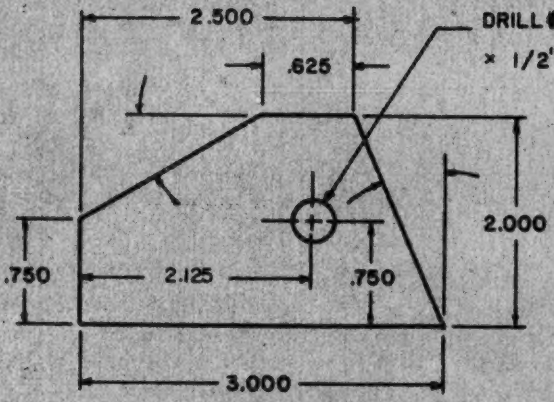
STEEL ROD TURNED TO:

A. 1.750
B. 1.437
C. 1.000
D. .812



MATERIAL — STEEL BAR BORED OUT AS PER SKETCH

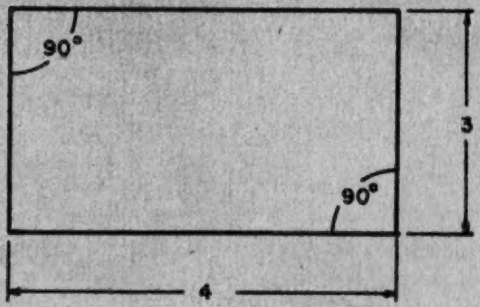




DRILL #8 REAM FOR .250 × 1/2" DOWEL PIN

(MATERIAL STEEL PLATE 1/4" THICK)

ONE PER STUDENT
1/16" x 3" x 4" STEEL
OR ALUMINUM PLATE



G. Give test.

H. Reteach, if necessary.

II. Instructional materials:

A. Objective sheet

B. Information sheet

C. Assignment sheets

1. Assignment Sheet #1--Identify Major Parts of Vernier Tools
2. Assignment Sheet #2--Select the Correct Vernier Tool
3. Assignment Sheet #3--Read the Vernier

D. Answers to assignment sheets

E. Job sheets

1. Job Sheet #1--Use Vernier Caliper to Take Inside, Outside, and Depth Measurements
2. Job Sheet #2--Use the Depth Vernier
3. Job Sheet #3--Use Vernier Height Gage for Layout and Inspection
4. Job Sheet #4--Use the Universal Bevel Protractor to Measure Angles

F. Test

G. Answers to test

III. Unit references:

A. *Starrett Tools.* Athol, MA: The L. S. Starrett Company, 1979.

B. *The Shop Tool Manual. Catalog No. STM-74.* North Kingston, RI: Brown and Sharpe Manufacturing Company, n.d.

C. *Mitutoyo Measuring Instruments. Catalog No. 3000.* Paramus, NJ: MTI Corp., 1978.

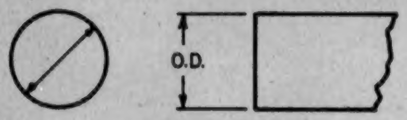
VERNIER MEASURING TOOLS
UNIT V

INFORMATION SHEET

I. Terms and definitions

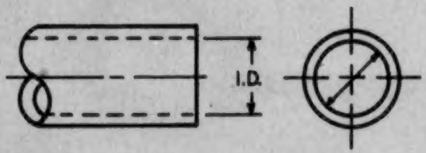
A. Outside diameter (OD)--Amount of material from one side to the other of a round object

Example:



B. Inside diameter (ID)--Inside measurement of a round hollowed-out part, bore or hole

Example:



C. Scriber--Sharp, pointed tool used to draw or mark lines on material for layout

D. Circular--A round surface

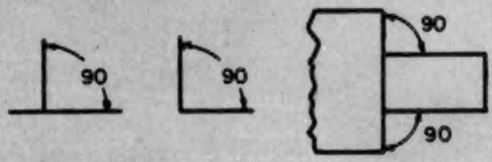
E. Length--Distance from one point to another

F. Reference surface--An important surface that is used for layout, machining, and inspections; used to take dimensions

G. Perpendicular--Two surfaces that intersect at a 90° angle

(NOTE: This is referred to as "square.")

Example:



H. Plane--A flat surface

I. Layout solution--A thin colored liquid (usually lacquer-based) used to paint on surface so scribed lines will show up

(CAUTION: LAYOUT SOLUTION STAINS CLOTHING!)

INFORMATION SHEET

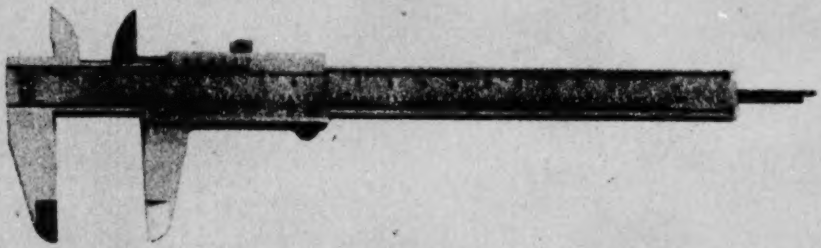
J. Surface plate--Black granite rectangular flat surface used for layout

K. Nibs--Small rectangular ends on calipers

L. Standard--Hardened and ground precision piece of steel used for checking or setting measuring tools

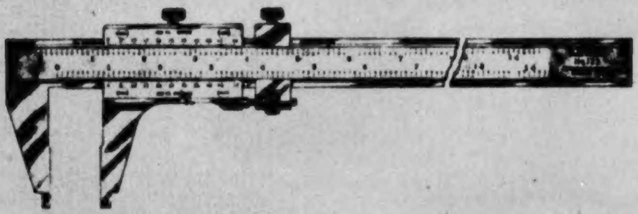
II. Basic types of vernier measuring tools

A. Universal vernier caliper



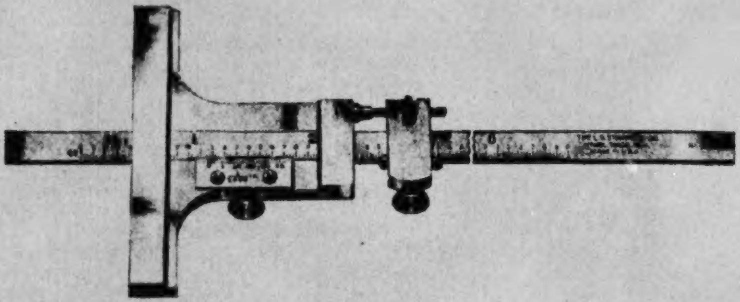
Used with permission of Brown & Sharpe Manufacturing Co.

B. Standard vernier caliper



Used with permission of The L. S. Starrett Company

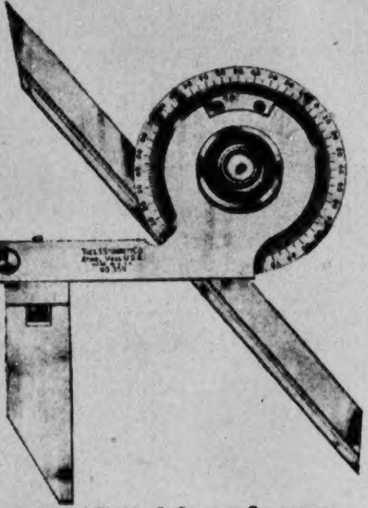
C. Vernier depth gage



Used with permission of The L. S. Starrett Company

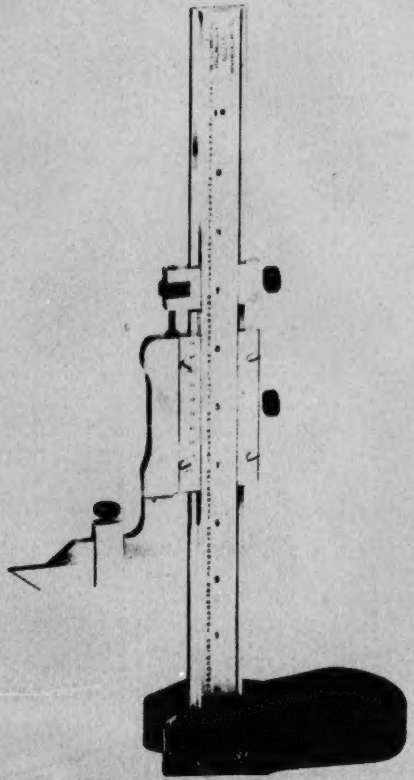
INFORMATION SHEET

D. Universal bevel protractor



Used with permission of The L. S. Starrett Company

E. Vernier height gage



Used with permission of The L. S. Starrett Company

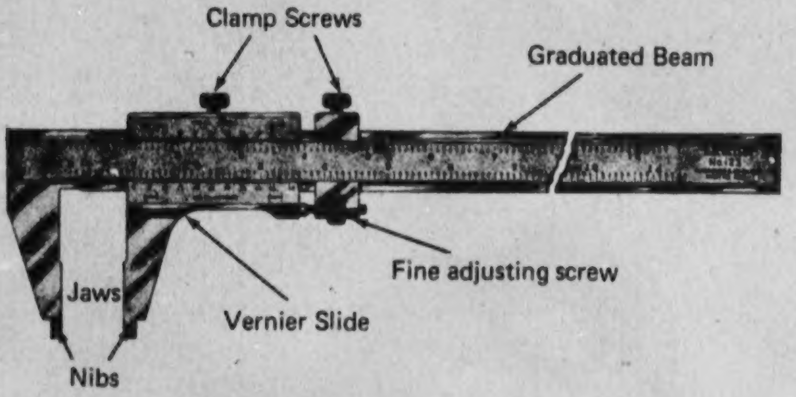
INFORMATION SHEET

III. Major parts of vernier measuring tools

A. Vernier calipers

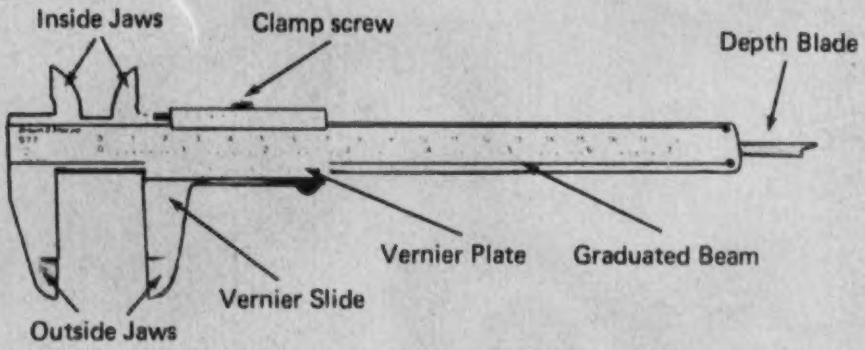
1. Standard vernier caliper

(NOTE: Some standard verniers have inside diameter measurements on the back side.)


Clamp Screws
Graduated Beam
Fine adjusting screw
Jaws
Vernier Slide
Nibs

Used with permission of The L. S. Starrett Company

2. Universal vernier caliper

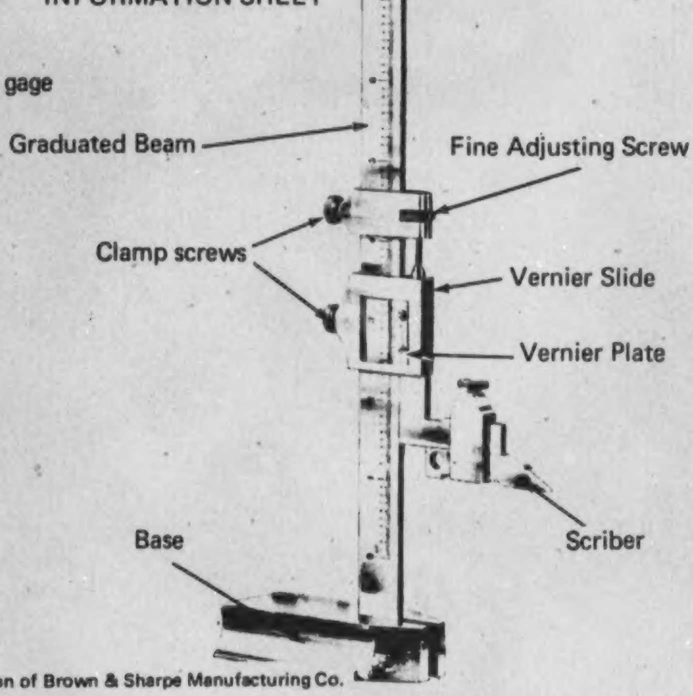

Inside Jaws
Clamp screw
Depth Blade
Vernier Plate
Graduated Beam
Vernier Slide
Outside Jaws

Used with permission of Brown & Sharpe Manufacturing Co.

(NOTE: Both standard and universal vernier calipers can be used for inside and outside measurements. However, a standard vernier caliper will not measure a hole any smaller than the thickness of the nibs. Universal vernier calipers can be used to measure small holes and take depth measurements.)

INFORMATION SHEET

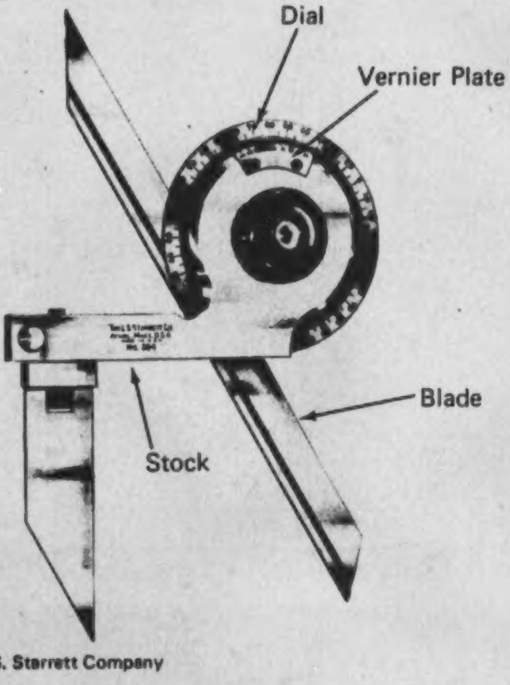
B. Vernier height gage


Graduated Beam
Fine Adjusting Screw
Clamp screws
Vernier Slide
Vernier Plate
Base
Scriber

Used with permission of Brown & Sharpe Manufacturing Co.

(NOTE: This tool is used on a surface plate and measures from the flat surface to the scriber.)

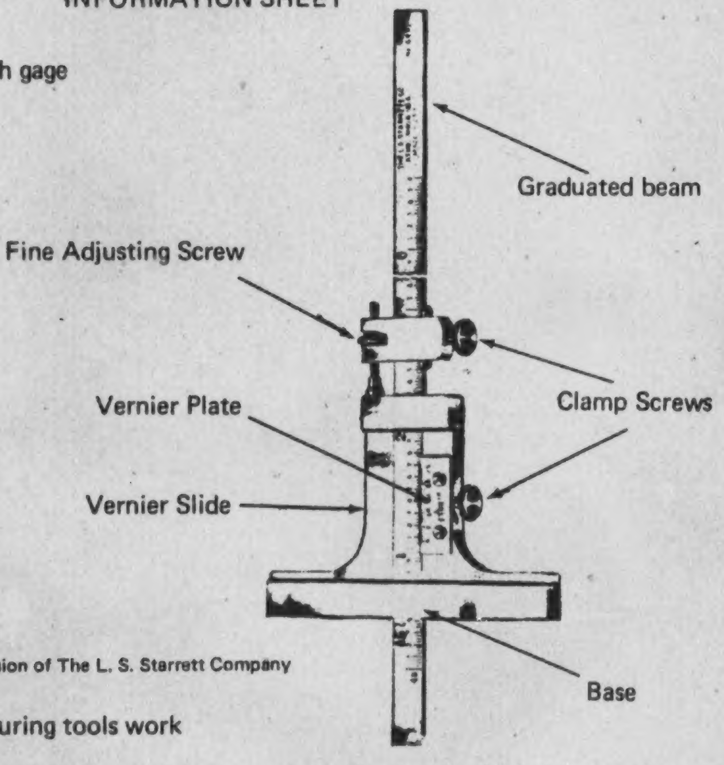
C. Universal bevel protractor


Dial
Vernier Plate
Blade
Stock

Used with permission of The L. S. Starrett Company

INFORMATION SHEET

D. Vernier depth gage

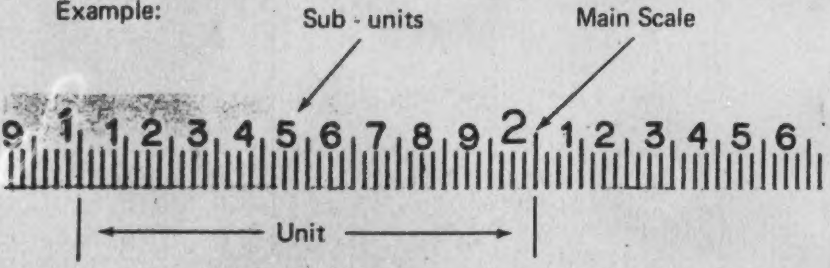

Graduated beam
Fine Adjusting Screw
Clamp Screws
Vernier Plate
Vernier Slide
Base

Used with permission of The L. S. Starrett Company

IV. How vernier measuring tools work

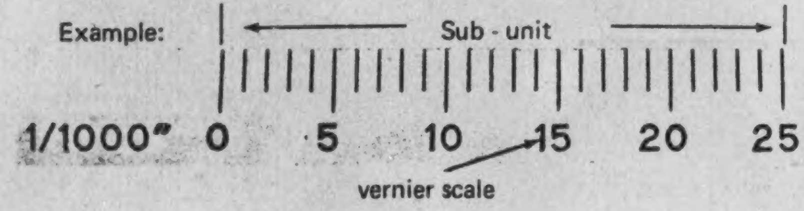
A. The vernier measuring tool has a main scale that is divided into units and sub-units

Example:


Sub - units
Main Scale
9 1 1 2 3 4 5 6 7 8 9 2 1 2 3 4 5 6
Unit

B. The vernier scale divides the sub-units into parts of sub-units

Example:

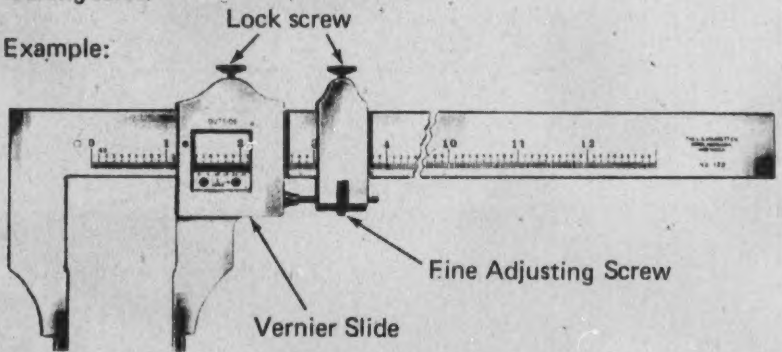

Sub - unit
1/1000"
0
5
10
15
20
25
vernier scale

(NOTE: The main scale and the vernier scale can be in any unit of measurement.)

INFORMATION SHEET

C. The vernier slide carries the vernier scale up and down the main scale; it can be adjusted with the fine adjusting screw and locked in place with the locking screw

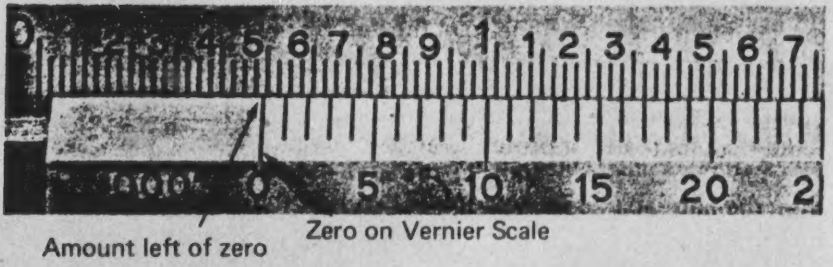
Example:


Lock screw
Fine Adjusting Screw
Vernier Slide

Used with permission of The L. S. Starrett Company

D. The reading is obtained by combining the readings of the two scales

Example:

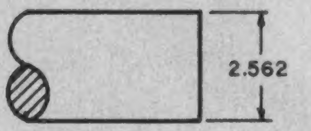

0 1 2 3 4 5 6 7 8 9 1 1 2 3 4 5 6 7
0 5 10 15 20 2
Amount left of zero
Zero on Vernier Scale

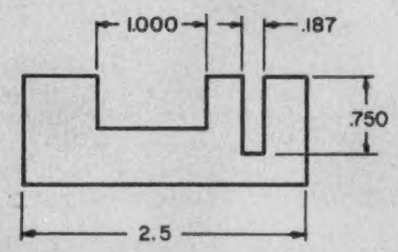
*The part of a unit that is added

V. Selecting the correct vernier measuring tool

A. Vernier caliper–Used to measure inside and outside diameters, inside dimensions, lengths, thicknesses, and depths

Examples:

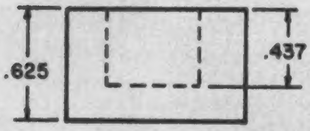


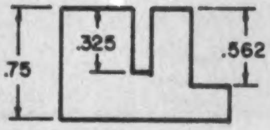

1.000
.187
.750
2.5

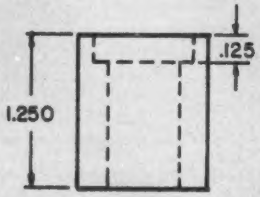
INFORMATION SHEET

B. Vernier depth gage--Used to measure depth of holes, slots, bores, counterbores

Examples:

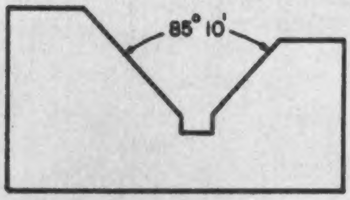


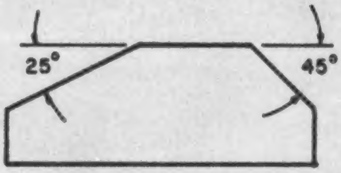




C. Universal bevel protractor--Used to measure or lay out precision angles

Examples:

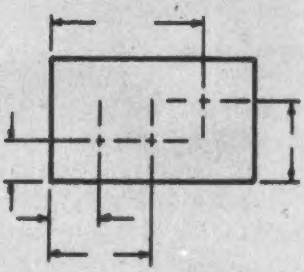


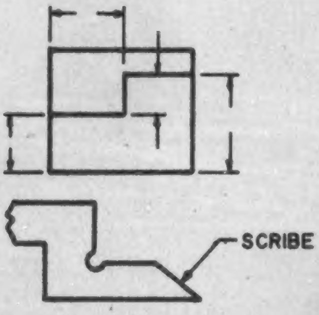


D. Vernier height gage--Used for precision layout and inspection of parts

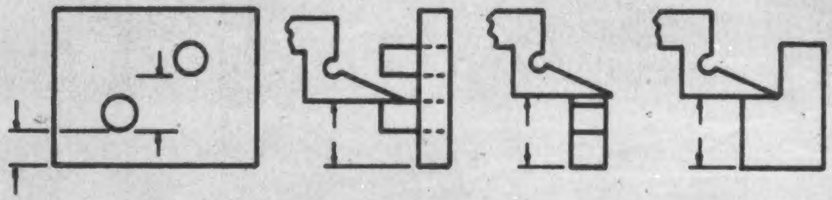
Examples:

LAYOUT





INSPECTION



INFORMATION SHEET

VI. Rules for proper care of vernier measuring tools

A. Storage and use--Always keep vernier measuring tool free of dirt, grease and other foreign matter; lay on clean shop towel, never directly on metal surface

B. Cleaning--After using, wipe with clean soft rag and apply a thin coat of light oil

C. Accuracy--Never throw these tools around; handle them carefully so they will maintain their accuracy for years

D. Lock screws--Make sure the lock screws are loosened before attempting to move the sliding jaw

E. Forced readings--Do not try to force a reading; it is easy to spring the jaws, causing the tool to lose its accuracy

F. Examining and checking--Examine the vernier and check it with a standard to ensure accuracy

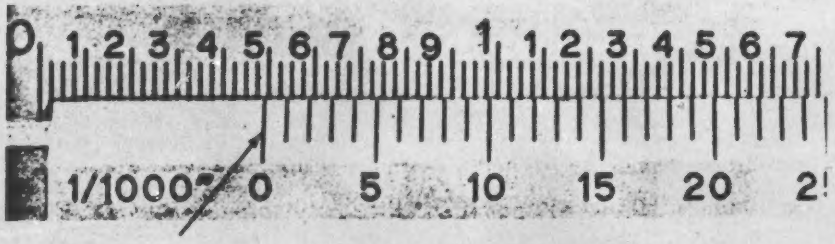
VII. Reading vernier measuring tools

A. Vernier caliper, vernier depth gage, vernier height gage

1. Look at beam graduations (main scale) and vernier scale to determine units of measurement

2. Note the amount to the left of the zero on the vernier scale and write it down

Example:

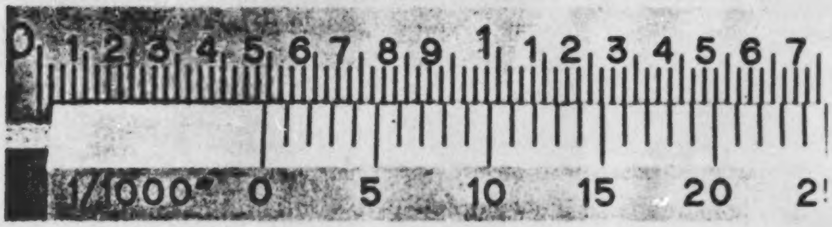


Left of zero = .475

INFORMATION SHEET

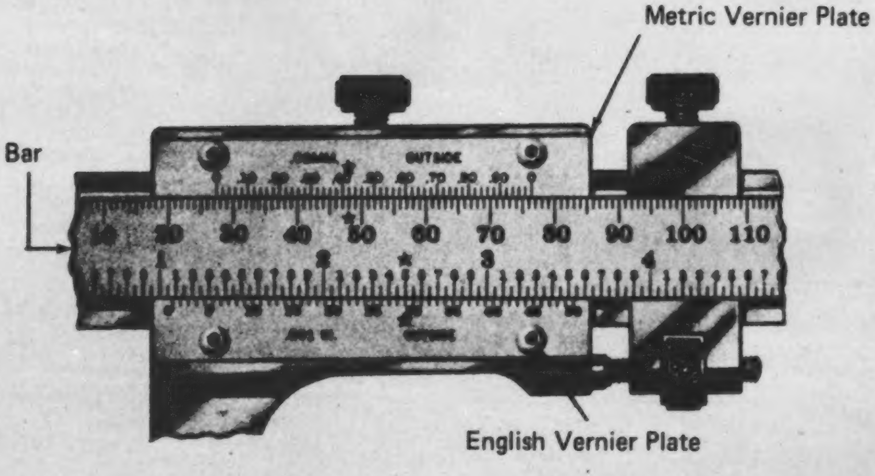
3. Look along the vernier scale until you find the line that lines up with one of the lines on the main scale; add that amount to the previous reading

Examples:


0 1 2 3 4 5 6 7 8 9 1 1 2 3 4 5 6 7
1/1000" 0 5 10 15 20 2

The 17 mark on the vernier lines up with a line on the main scale, and each line on the vernier scale equals .001, so add .017 to your reading

.475 main scale reading
.017 vernier scale reading
.492 total reading


Metric Vernier Plate
Bar
10 20 30 40 50 60 70 80 90 100 110
1 2 3 4
English Vernier Plate

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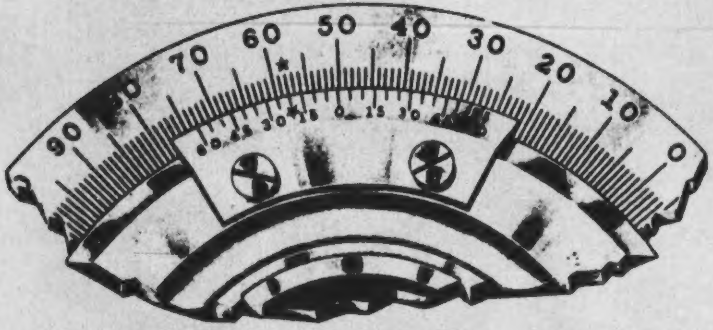
Note the zero line is past 1.050, the 29 line on the vernier scale is lined up, so the reading is 1.050 + .029 = 1.079 thousandths of an inch

INFORMATION SHEET

B. Universal bevel protractor

1. Main scale is divided into 10 degree lines (10°) and each 10 degrees is marked with lines equaling 1 degree
2. Vernier scale is divided into 60 minutes (60') right and left of a zero mark
3. Each 60 minutes is divided by lines every 5 minutes and numbered every 15 minutes

Example:



Used with permission of The L. S. Starrett Company

(NOTE: 1° = 60'.)

If the vernier scale is to the left of the zero of the main scale, the minute reading is obtained from the left side of the vernier scale. Note in the above example the zero line is on the left side. It is past 50° but less than 51°. The 20' mark on the vernier scale is lined up wth a line on the main scale, so it is 20' more than 50°

50° + 20' = 50°20'

VERNIER MEASURING TOOLS
UNIT V

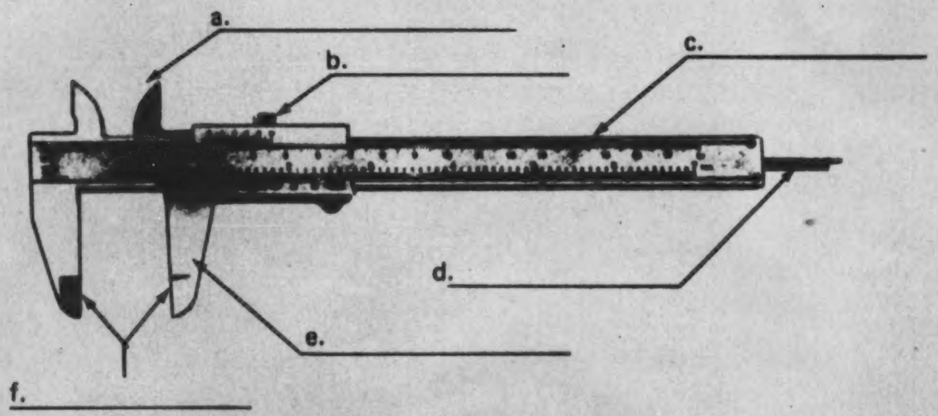
ASSIGNMENT SHEET #1–IDENTIFY MAJOR PARTS OF VERNIER TOOLS

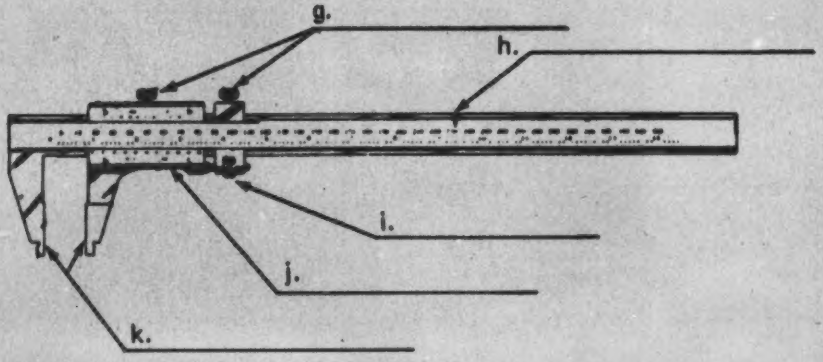
NAME______________________________ SCORE_______________

Knowing the parts of verniers will help you communicate with your instructor and learn how to use and read these tools accurately.

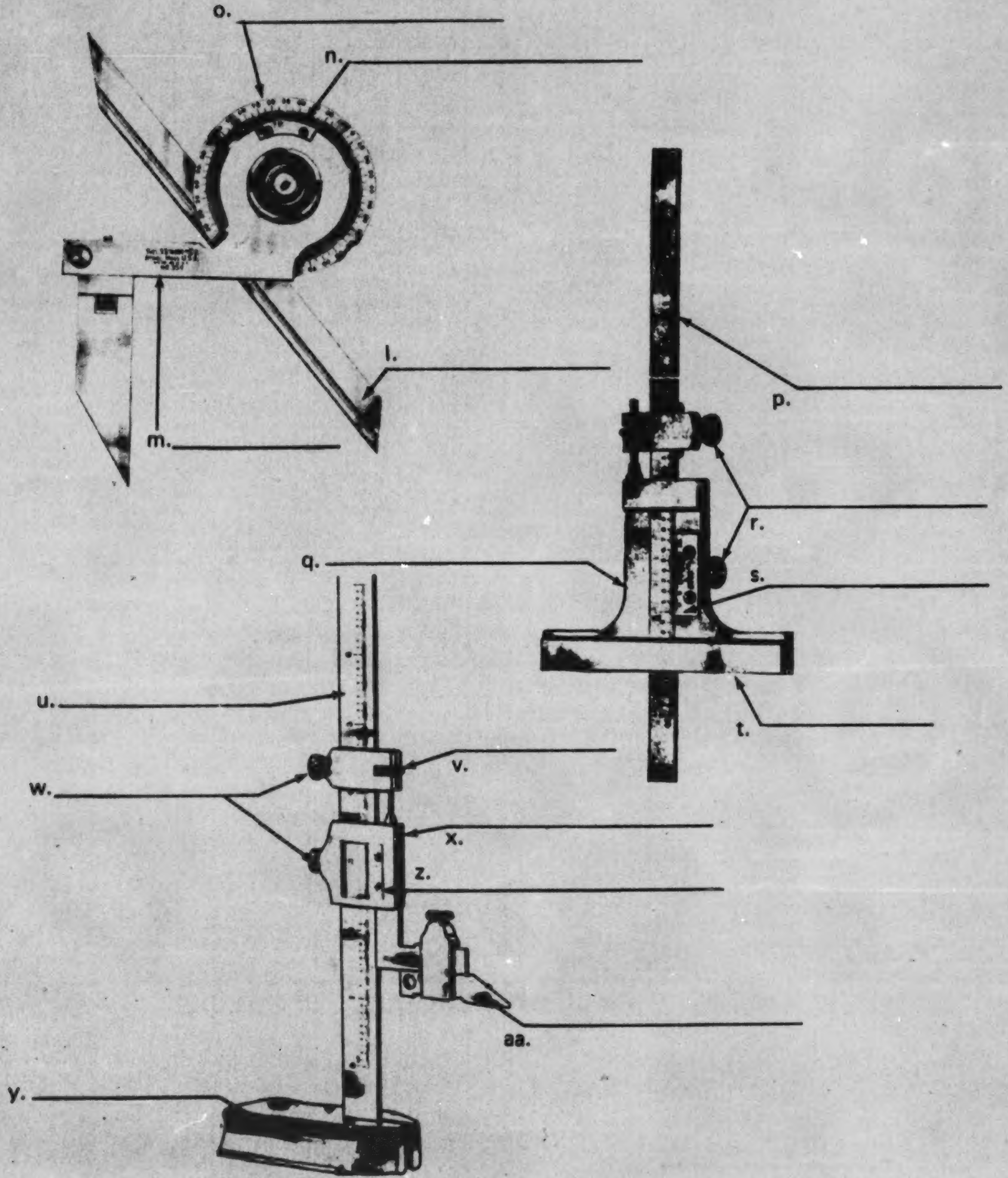
Identify the parts of the vernier tools pictured below. Write the correct names in the blanks provided. Answers may be used more than once.

Inside jaw
Outside jaws
Scriber
Vernier slide
Dial
Stock
Fine adjusting screw
Base
Vernier slide
Clamp screw
Nibs
Blade
Graduated beam
Depth blade





ASSIGNMENT SHEET #1


o.
n.
l.
m.
p.
r.
q.
s.
t.
u.
v.
w.
x.
z.
aa.
y.

VERNIER MEASURING TOOLS
UNIT V

ASSIGNMENT SHEET #2--SELECT THE CORRECT VERNIER TOOL

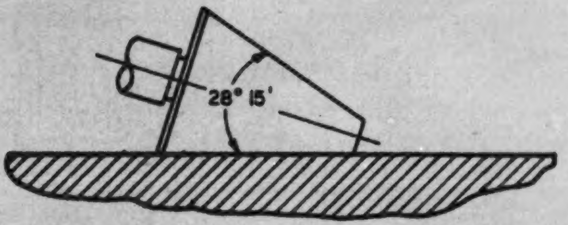
NAME________________________________ SCORE________________

Select the type of vernier measuring tool you would use in each situation by writing the correct names in the blanks provided.

(NOTE: Some of the tools may be used more than once.)

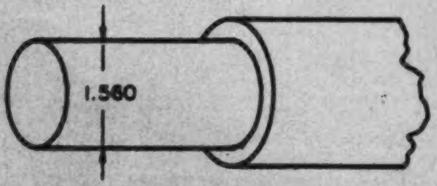
Vernier caliper	Vernier height gage
Universal bevel protractor	Vernier depth gage

1. Used to measure the included angle of this taper plug gage________________________

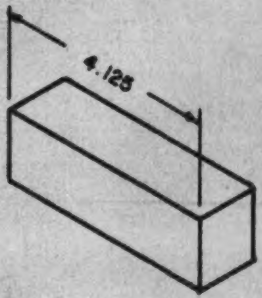


2. Used to measure diameter of a part being turned to a certain dimension

____



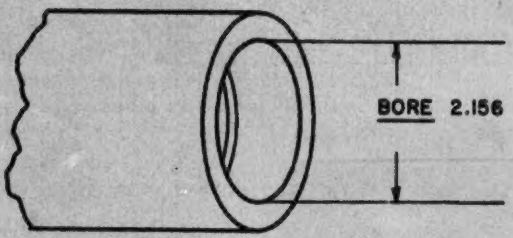
3. Used to measure the length of a part being milled to length______________________



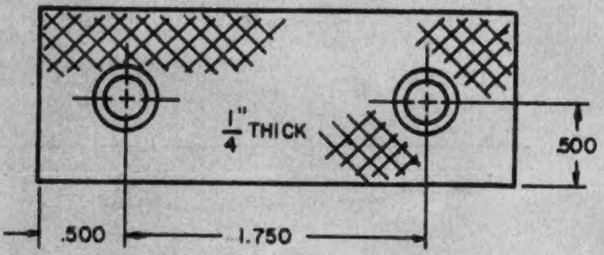
__________________c.

ASSIGNMENT SHEET #2

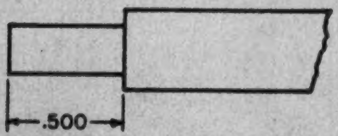
4. Used to measure this inside bore______________________________



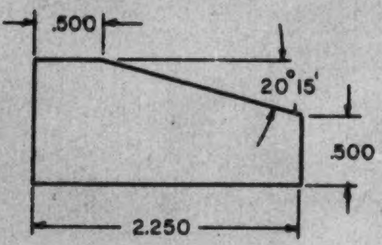
5. Used to lay out the location of these holes to be drilled__________________


1/4" THICK
.500
.500
1.750

6. Used to measure the length of this shoulder________________________



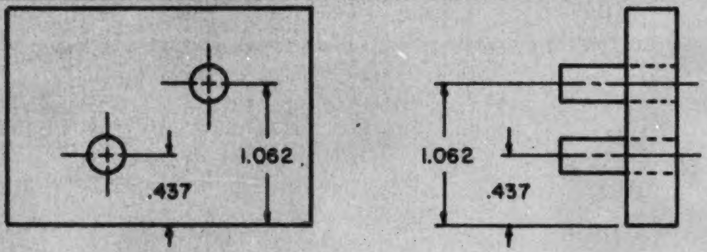
7. Used to lay out this angle___________________________________


.500
20°15'
.500
2.250

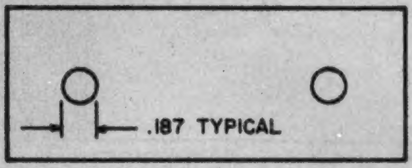
ASSIGNMENT SHEET #2

8. Used to measure the distance of pins from their reference surface

____

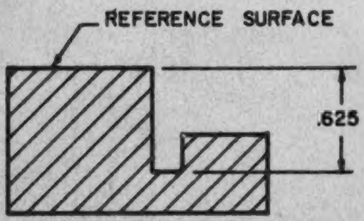

1.062
.437
1.062
.437

9. Used to measure the diameter (.187) of the drilled holes________________________


.187 TYPICAL

10. Used to measure the distance of the slot from the reference surface

____


REFERENCE SURFACE
.625

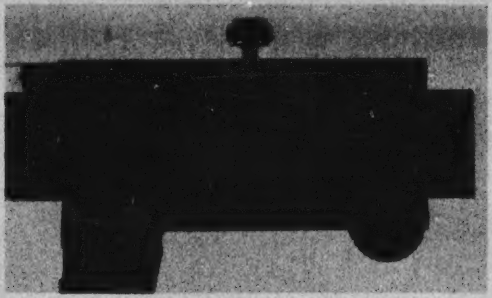
VERNIER MEASURING TOOLS
UNIT V

ASSIGNMENT SHEET #3--READ THE VERNIER

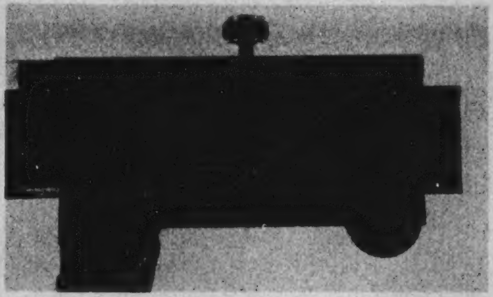
NAME______________________________ SCORE____________

It is most important to be highly skilled in reading vernier measuring tools quickly and accurately. Read the measurements shown below and write the answers in the blanks provided.

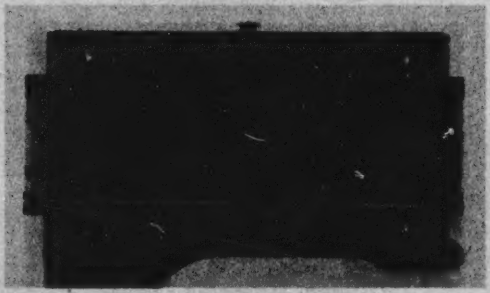
(NOTE: Make sure the decimal point, degree, and minute symbols are used in proper place.)



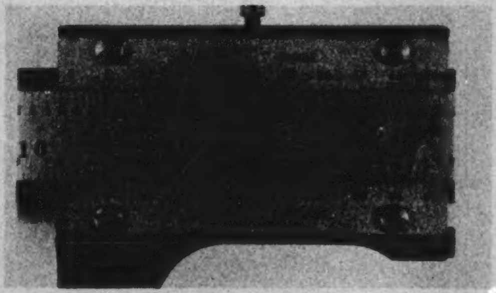
a. ____________________



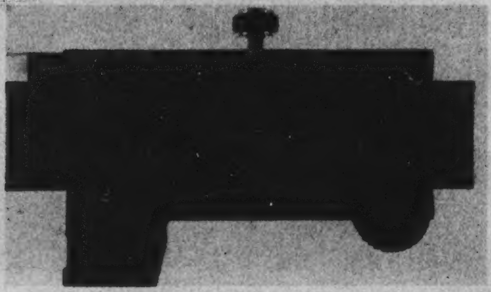
b. ____________________



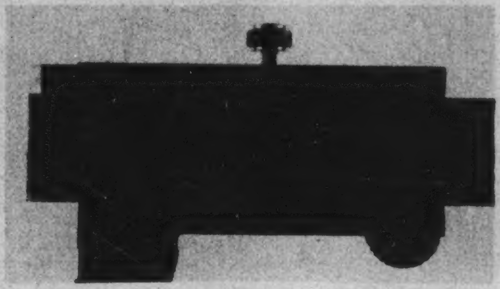
c. ____________________



d. ____________________



e. ____________________



f. ____________________

VERNIER MEASURING TOOLS
UNIT V

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

a. Inside jaw
b. Clamp screw
c. Graduated beam
d. Depth blade
e. Vernier slide
f. Outside jaws
g. Clamp screws
h. Graduated beam
i. Fine adjusting screw
j. Vernier slide
k. Nibs
l. Blade
m. Stock
n. Vernier plate
o. Dial
p. Graduated beam
q. Vernier slide
r. Clamp screws
s. Vernier plate
t. Base
u. Graduated beam
v. Fine adjusting screw
w. Clamp screw
x. Vernier slide
y. Base
z. Vernier plate
aa. Scriber

Assignment Sheet #2

a. Vernier height gage
b. Vernier caliper
c. Vernier caliper
d. Vernier caliper
e. Universal bevel protractor
f. Vernier caliper or vernier depth gage
g. Vernier height gage
h. Universal bevel protractor
i. Vernier caliper
j. Vernier caliper or vernier depth gage

Assignment Sheet #3

a. 3.800
b. 1.432
c. 1.032
d. 10.290
e. .871
f. 2.070

VERNIER MEASURING TOOLS
UNIT V

JOB SHEET #1--USE VERNIER CALIPER TO TAKE INSIDE, OUTSIDE, AND DEPTH MEASUREMENTS

I. Tool--6 or 8" universal vernier caliper

II. Materials

   A. Pre-machined steel bar turned with four dimensions

   B. Pre-machined steel, drilled and bored

III. Procedure for taking inside measurements

   A. Grasp the vernier caliper in the right hand with vernier scale up

   B. Grasp part with left hand

   C. Use the thumb of the right hand to adjust caliper so inside portion of vernier will slide in bore, then open the jaw by sliding the slide toward your right until you feel a slight amount of pressure; take reading before removing from part (Figures 1 and 2)

FIGURE 1

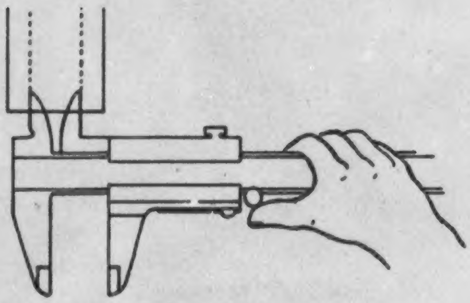
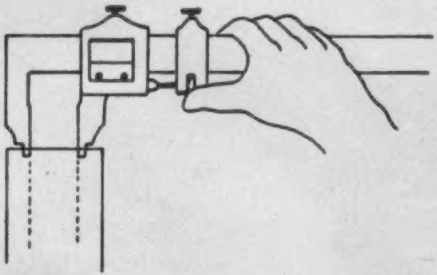


FIGURE 2



(NOTE: Be careful not to apply too much pressure, but keep the jaws squarely in the bore. See Figures 3 and 4 for example.)

FIGURE 3

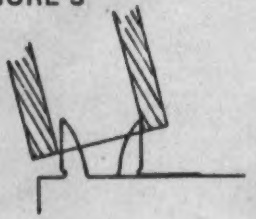
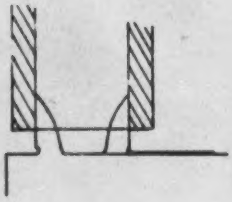


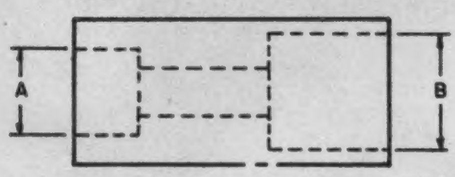
FIGURE 4



JOB SHEET #1

D. Measure each of the inside bores and record your readings (Figure 5)

FIGURE 5



________________ A

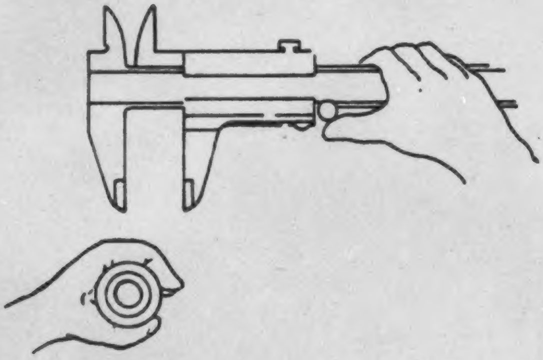
________________ B

IV. Procedure for taking outside measurements

A. Pick up the vernier caliper with your right hand so you are looking at the vernier scale

B. Grasp the part to be measured in the left hand parallel to your body (Figure 6)

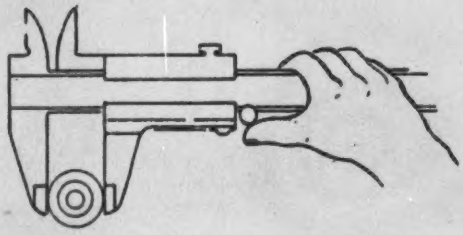
FIGURE 6



(NOTE: The thumb of the right hand can slide the sliding member along the beam of the vernier.)

C. Place the part between the two jaws close to beam, if possible; move the sliding member against the part by applying slight pressure with the thumb; take reading before removing part (Figure 7)

FIGURE 7

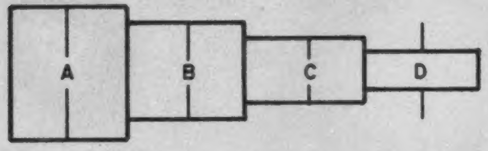


(CAUTION: Do not to apply so much pressure that you spring the caliper.)

JOB SHEET #1

D. Start measuring at one end and work toward the other. Write each dimension in the spaces provided (See Figure 8.)

FIGURE 8



______________ A

______________ B

______________ C

______________ D

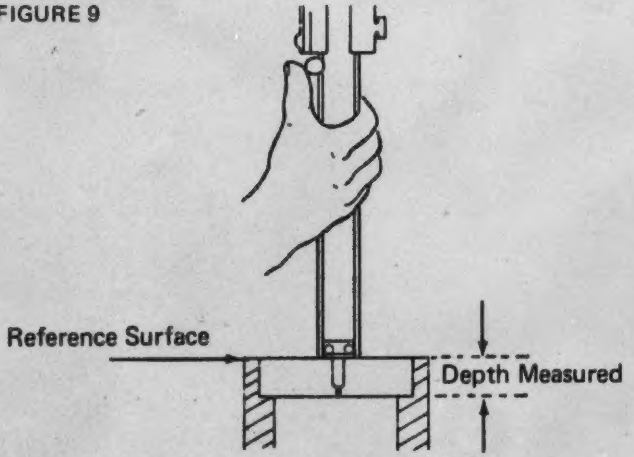
V. Procedure for taking depth measurements

A. Place the part to be measured on the bench with the deeper bore resting on the table

B. Grasp the vernier caliper and place the base of the beam on the reference surface

C. Using one hand to hold the caliper perpendicular to the reference surface, use the free hand to move the slide down until you feel the blade make contact with the lip or surface to be measured; take measurement before removing part (Figure 9)

FIGURE 9



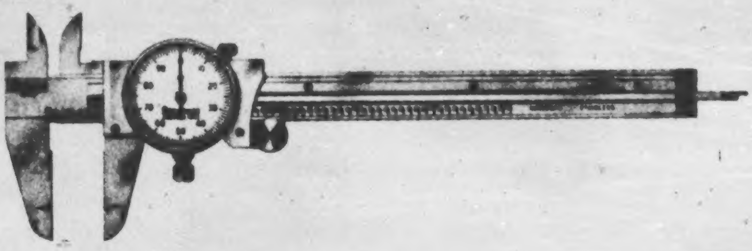
D. Record your reading ______________________ a

JOB SHEET #1

E. Turn part end for end and measure the depth of the bore on the other end; record your reading ______________________ b

(NOTE: Some vernier calipers have a dial. The application and use is the same as the universal vernier caliper, but the dial makes it easier and faster to read. See Figure 10.)

FIGURE 10



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VERNIER MEASURING TOOLS
UNIT V

JOB SHEET #2--USE THE DEPTH VERNIER

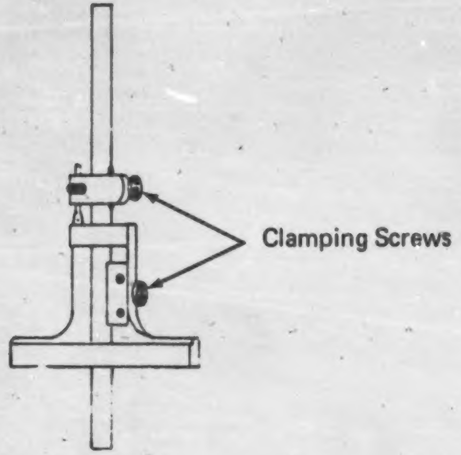
I. Tool--Depth vernier

II. Material--Premachined steel, drilled and bored

III. Procedure for determining depth of one side

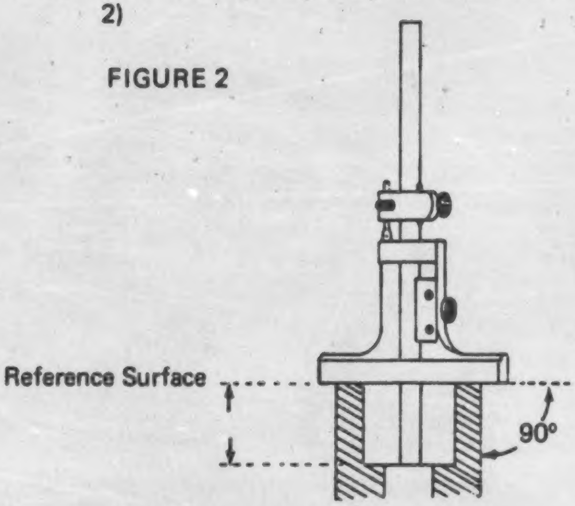
A. Pick up depth gage and loosen the clamping screws (Figure 1)

FIGURE 1


Clamping Screws

B. Hold the base squarely on the surface you are measuring from (Figure 2)

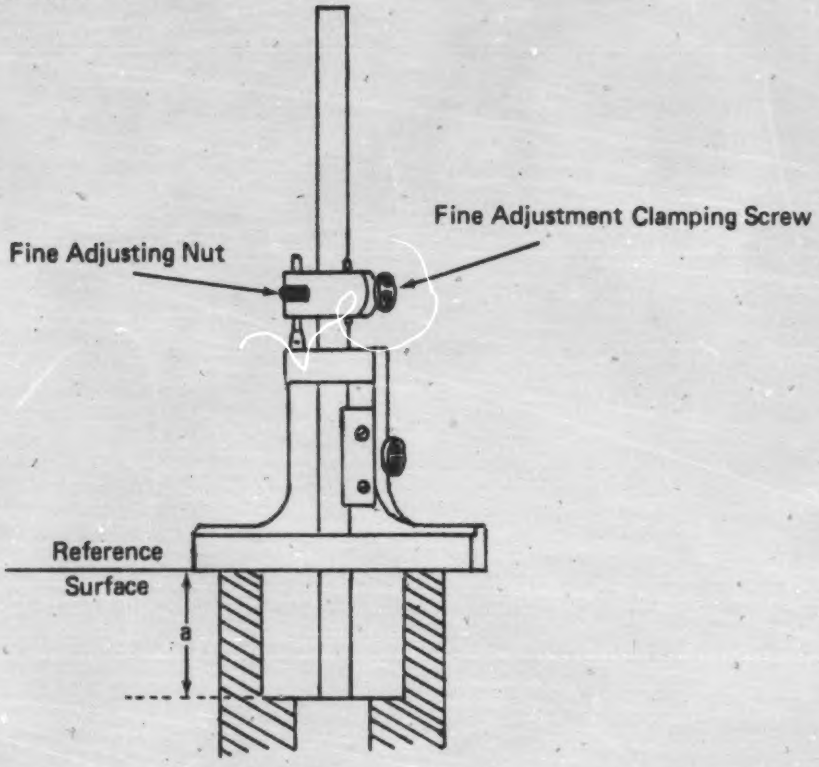
FIGURE 2


Reference Surface
90°

JOB SHEET #2

C. Slide the graduated beam down until you feel it make contact with the surface you are measuring; tighten the clamping screws that lock the fine adjustment to the beam; take measurement before removing part (Figure 3)

FIGURE 3


Fine Adjustment Clamping Screw
Fine Adjusting Nut
Reference Surface
a

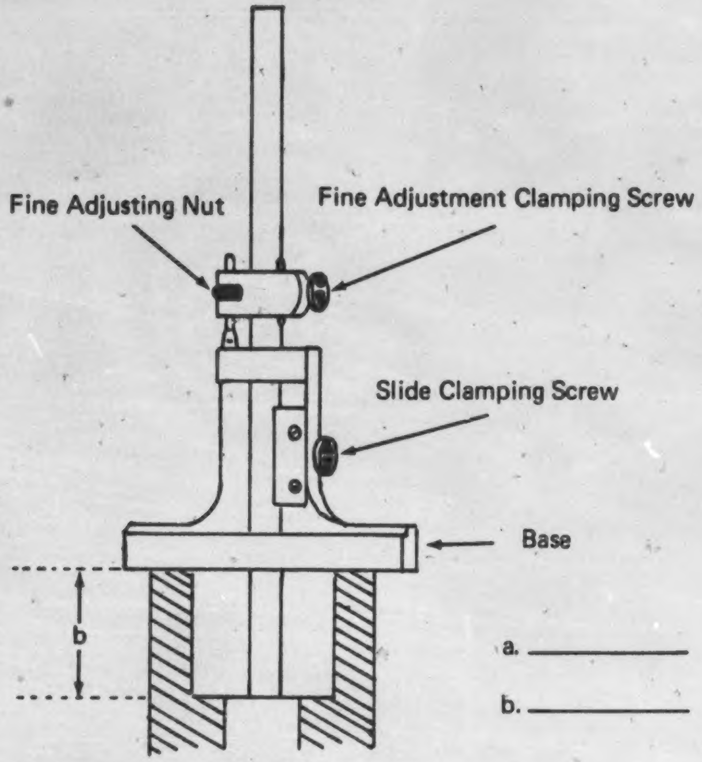
D. Tighten the slide clamp screw and remove the depth gage

E. Read vernier and record reading (See blanks provided in Figure 4)

JOB SHEET #2

F. Turn part end for end and repeat steps A through F to obtain dimension B; record your reading (Figure 4)

FIGURE 4


Fine Adjusting Nut
Fine Adjustment Clamping Screw
Slide Clamping Screw
Base
b

a. ____________

b. ____________

VERNIER MEASURING TOOLS
UNIT V

JOB SHEET #3--USE THE VERNIER HEIGHT GAGE FOR LAYOUT AND INSPECTION

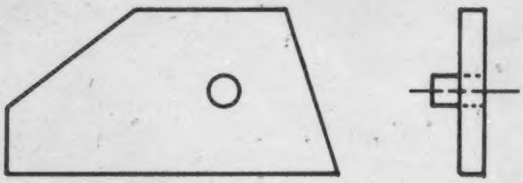
I. Tools and equipment

- A. 12" or 18" vernier height gage
- B. 4" angle blade
- C. Surface plate
- D. Small clamp
- E. Hand scriber
- F. Layout solution

II. Materials

- A. Pre-machined block with dowel pin (Figure 1)

FIGURE 1

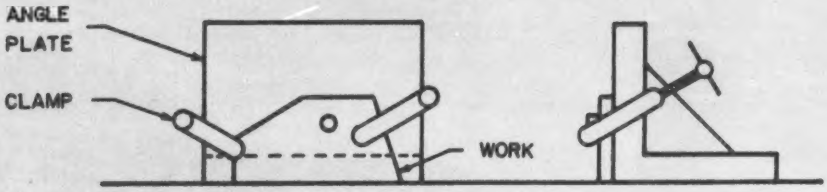


- B. Pre-machined plate 1/16" x 3" x 4" aluminum or steel

III. Procedure for inspection

- A. Pick up height gage, wipe off excessive oil and clean base
- B. Clean and wipe off surface and angle plate
- C. Hold part to angle plate so reference edge is on surface plate using one hand or small clamps (Figure 2)

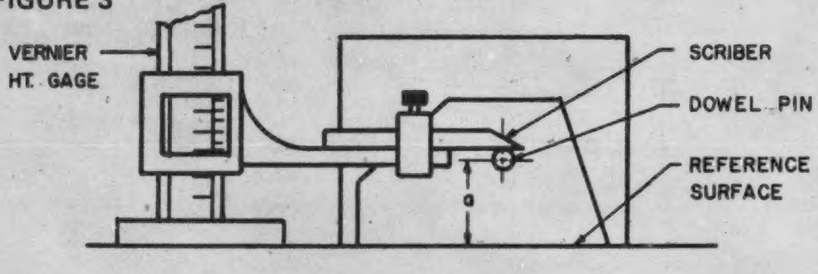
FIGURE 2



JOB SHEET #3

D. Bring the bottom of the scriber gently down on the dowel pin (Figure 3)

FIGURE 3


VERNIER
HT. GAGE
SCRIBER
DOWEL PIN
REFERENCE
SURFACE
a

E. Record your reading ______________________

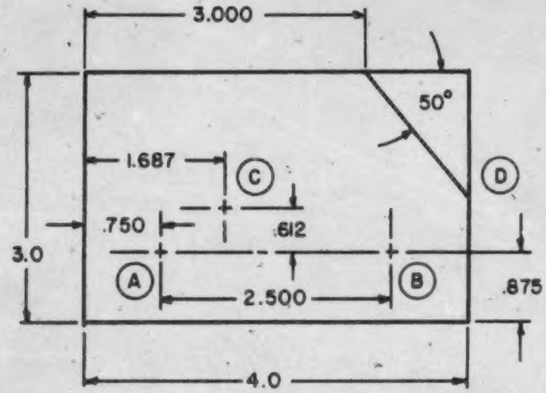
(NOTE: Subtract 1/2 of dowel pin diameter from reading.)

F. Turn part over, and repeat steps c and d and record other distance________

(NOTE: Instead of using the scriber to obtain these dimensions you could have used a dial test indicator. This technique will be discussed later in units on dial indicator uses.)

IV. Procedure for layout (See Figure 4)

FIGURE 4


3.000
50°
1.687
C
D
.750
.612
3.0
A
B
2.500
.875
4.0

A. Prepare metal for layout by painting or spraying layout solution on metal

(NOTE: Do not apply solution too heavily; it will crack off, making it hard to see lines.)

B. Set part on surface plate with 4" side down; clamp or hold work to angle plate (Figure 4)

C. Set vernier height gage on .875 and scribe lines for locations A and B

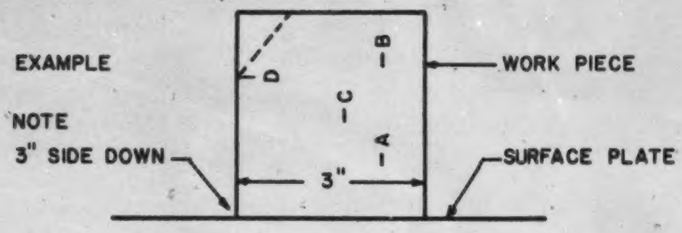
(NOTE: Try to keep lines as short as possible.)

JOB SHEET #3

D. Set vernier height gage for location C by adding .625 to .875 for a total 1.500 and scribe line

E. Unclamp and put 3" reference side down and reclamp (Figure 5)

FIGURE 5


EXAMPLE
NOTE
3" SIDE DOWN
D
C
A
B
3"
WORK PIECE
SURFACE PLATE

F. Set vernier height gage on .750 and scribe line at position A

G. Reset gage to 1.687 and scribe location C

H. Reset gage to 3.500 and scribe location B

I. Reset and scribe 3.000 line on corner (location D)

VERNIER MEASURING TOOLS
UNIT V

JOB SHEET #4--USE THE UNIVERSAL BEVEL PROTRACTOR TO MEASURE ANGLES

I. Tools

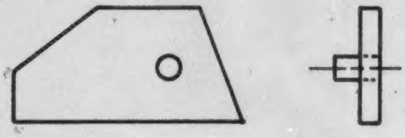
A. Universal bevel protractor

B. Scriber

II. Material

A. Pre-machined block with dowel pin (Figure 1)

FIGURE 1



B. Pre-machined plate 1/16" x 3" x 4" aluminum or steel

III. Procedure

A. Grasp the bevel protractor in the left hand and the part in the right hand

B. Place the reference side of the part (side from which angle is to be measured) securely against the stock of the protractor

C. Adjust the blade of the protractor until it makes solid contact with the side of the angle or place the stock on the surface plate

D. Place the part in the correct plane; then adjust the blade until it makes solid contact with the angle to be measured (Figures 2 and 3)

FIGURE 2

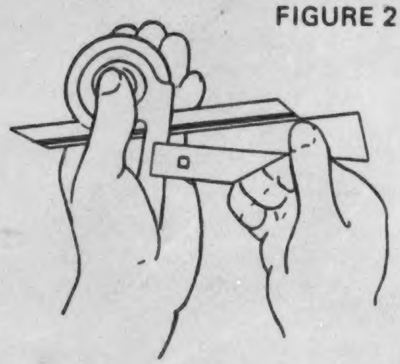
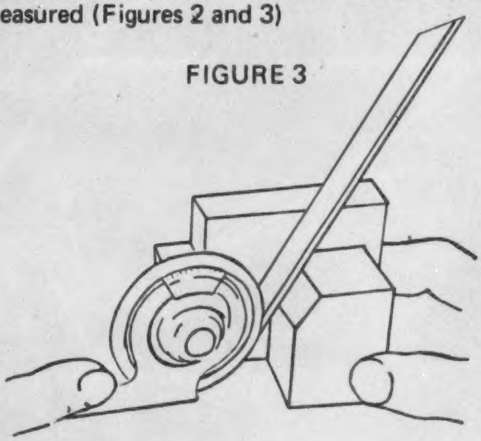


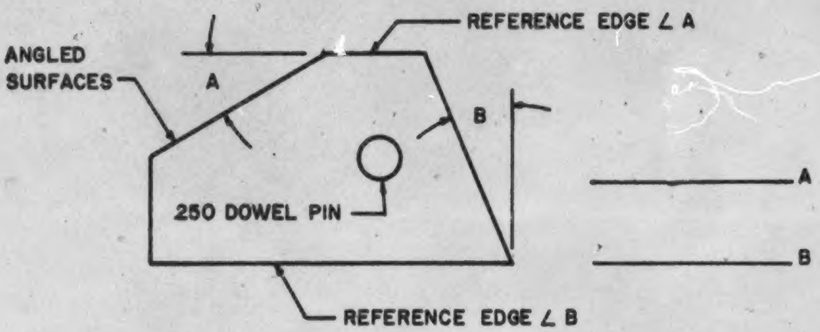
FIGURE 3



JOB SHEET #4

E. Measure the two angles and record your measurements (See Figure 4)

FIGURE 4


REFERENCE EDGE ∠ A
ANGLED SURFACES
A
B
250 DOWEL PIN
A
B
REFERENCE EDGE ∠ B

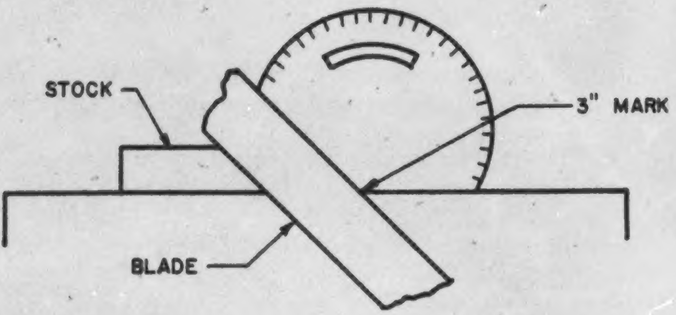
(NOTE: Be sure to use the correct symbols--degree [°] and minute [′].)

(NOTE: This tool is used in the same way when layout is the job.)

F. Set bevel protractor on 50°0′

G. Place stock firmly to reference edge so blade of protractor intersects 3" line and scribe angle (Figure 5)

FIGURE 5


STOCK
3" MARK
BLADE

H. Scribe lines

VERNIER MEASURING TOOLS
UNIT V

TEST

NAME____ SCORE__________

1. Match terms associated with vernier measuring tools to the correct definitions. Write the correct numbers in the blanks provided.

_____a. A round surface

_____b. A flat surface

_____c. Inside measurement of a round hollowed-out part, bore, or hole

_____d. A thin colored liquid (usually lacquer-based) used to paint on surface so scribed lines will show up

_____e. Amount of material from one side to the other of a round object

_____f. Sharp, pointed tool used to draw or mark lines on material for layout

_____g. Two surfaces that intersect at a 90° angle

_____h. An important surface that is used for layout, machining, and inspections; used to take dimensions

_____i. Distance from one point to another

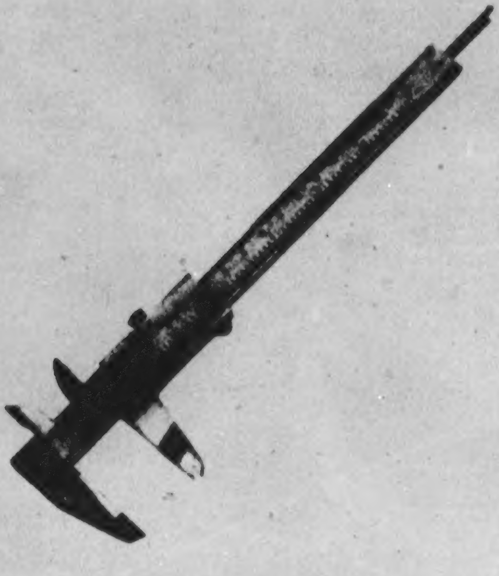
_____j. Black granite rectangular flat surface used for layout

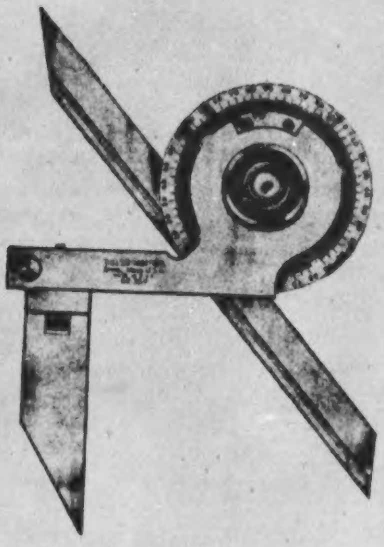
_____k. Small rectangular ends on calipers

_____l. Hardened and ground precision piece of steel used for checking or setting measuring tools

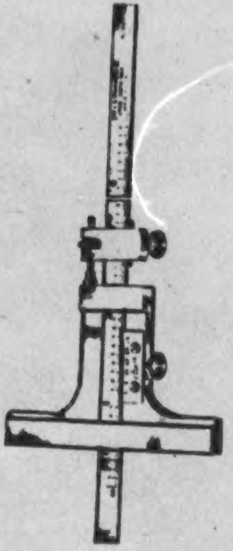
1. Outside diameter (OD)
2. Inside diameter (ID)
3. Scriber
4. Circular
5. Length
6. Reference surface
7. Surface plate
8. Plane
9. Layout solution
10. Standard
11. Perpendicular
12. Nibs

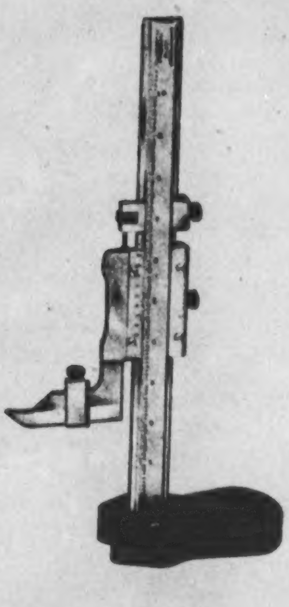
2. Label basic types of vernier measuring tools. Write the correct names in the blanks provided.



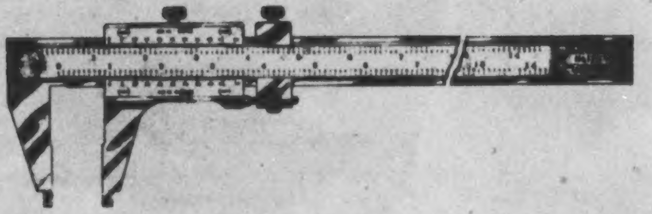


a. ______________________________ b. ______________________________





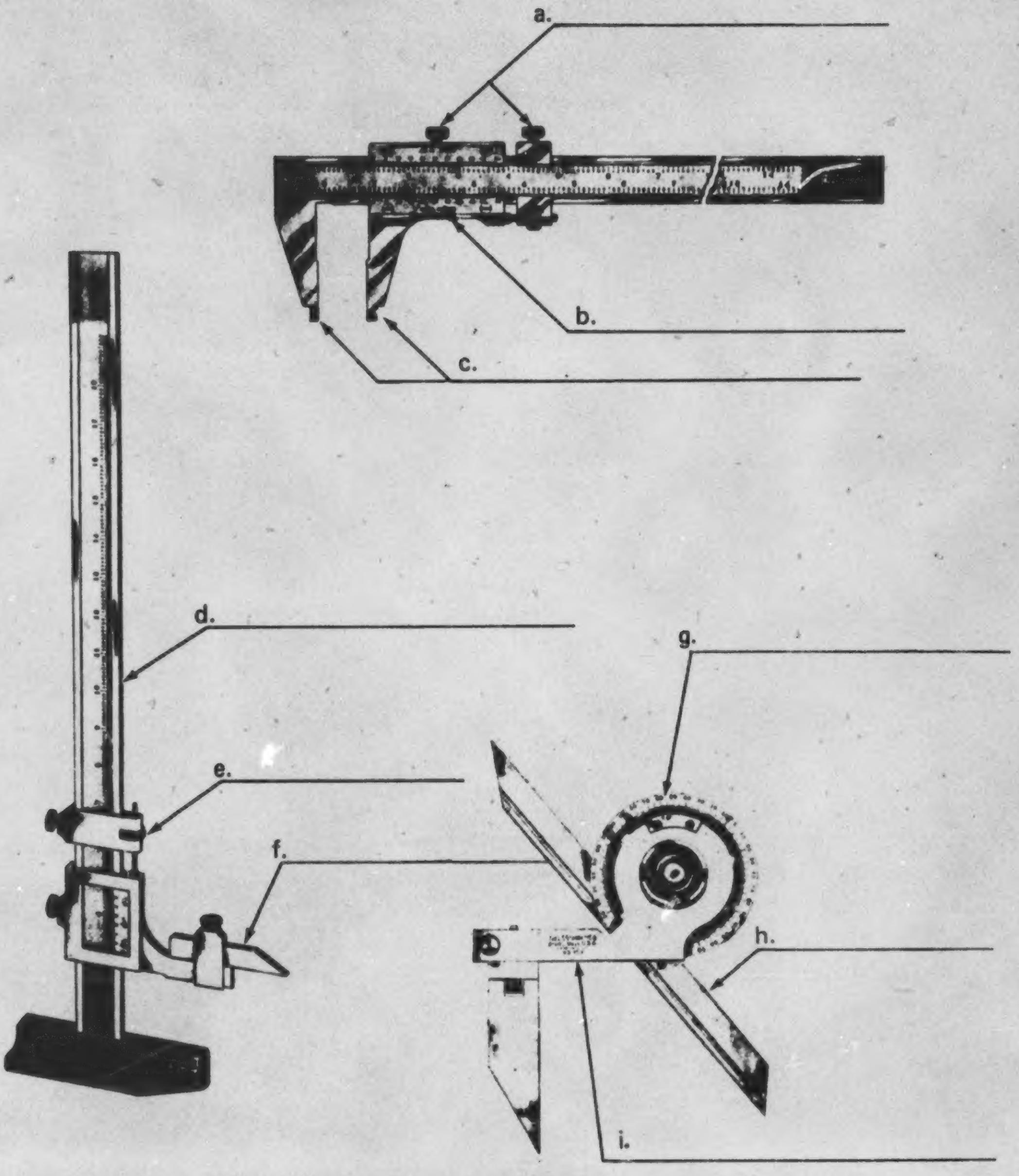
c. ______________________________ d. ______________________________

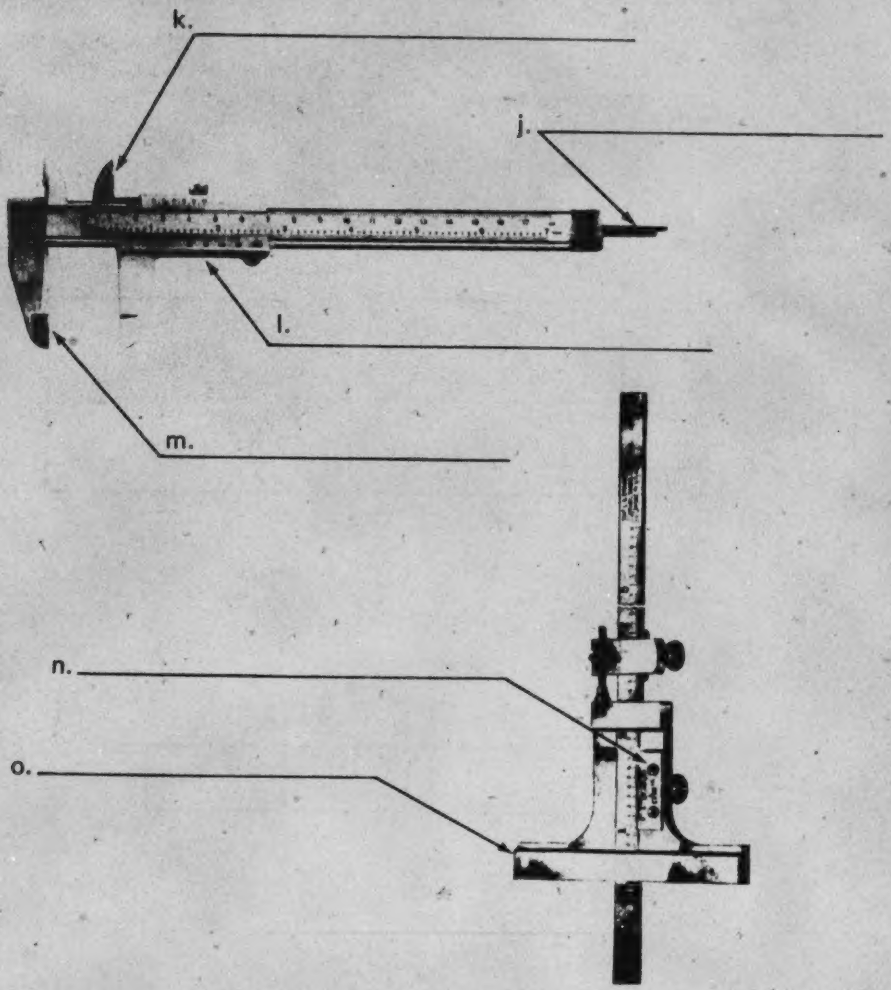


e. ______________________________

3. Identify the major parts of the vernier measuring tools shown below. Write the correct names in the blanks provided. A part name may be used more than once.

Clamp screw(s)
Outside jaws
Inside jaws
Vernier plate
Graduated beam
Fine adjusting screw
Depth blade
Vernier slide
Scriber
Base
Stock
Nibs
Blade
Dial





4. Describe how vernier measuring tools work.

a. Main scale--

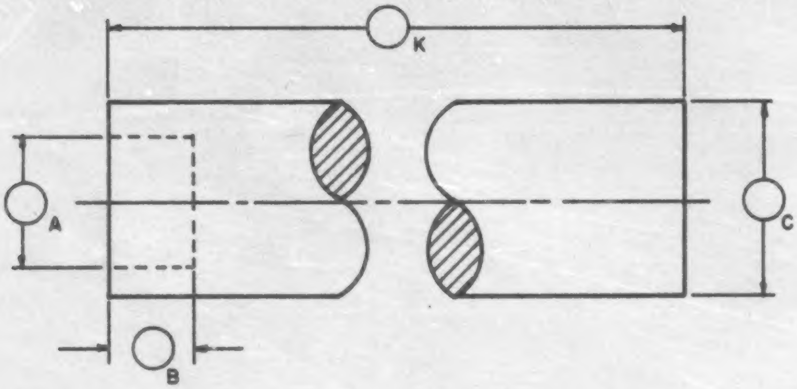
b. Vernier scale--

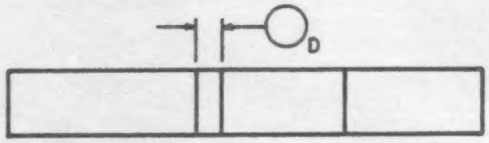
c. Vernier slide--

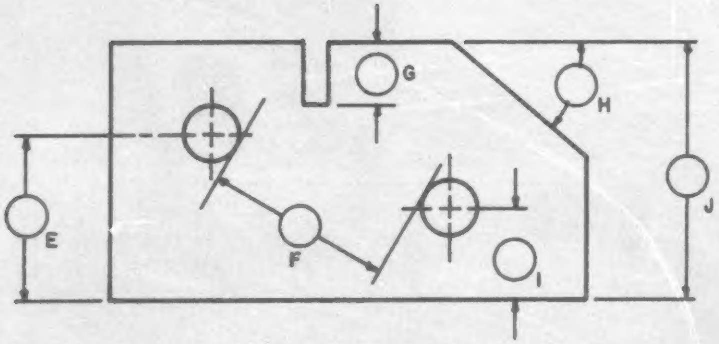
d. The reading--

5. Select the correct vernier measuring tool. Place the number of the correct tool in the circles provided. If more than one tool can be used, write the number of the most commonly-used tool.

1. Vernier caliper
2. Vernier height gage
3. Universal bevel protractor
4. Vernier depth gage







6. State the rules for proper care of vernier measuring tools in the blanks provided.
   a. Storage and use--____________________________________

   ____

   ____

   b. Cleaning--____________________________________

   ____

   c. Accuracy--____________________________________

   ____

   d. Lock screws--____________________________________

   ____

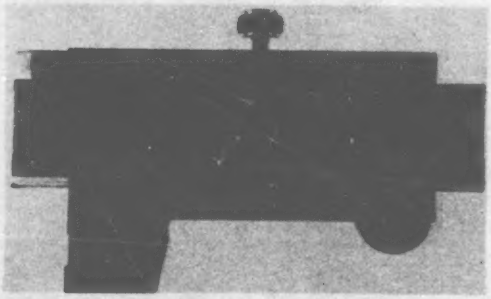
   e. Forced readings--____________________________________

   ____

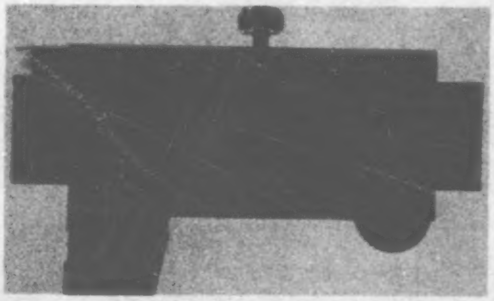
   f. Examining and checking--____________________________________

   ____

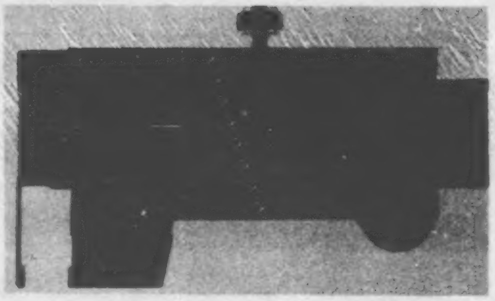
7. Read vernier measuring tools for each setting pictured below and on the next page. Write the correct answers in the blanks provided.



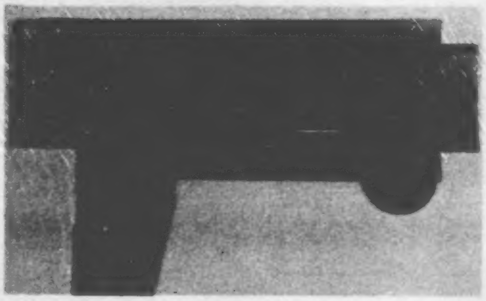
a. ____________________



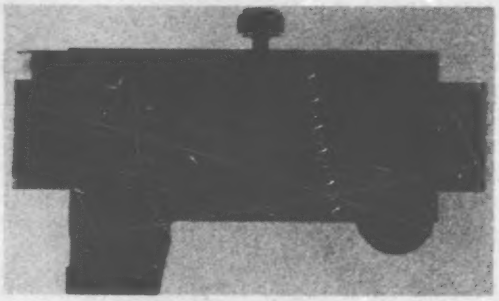
b. ____________________



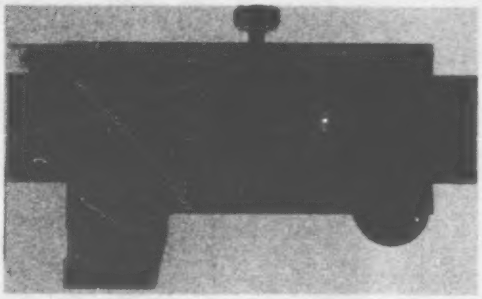
c. ____________________



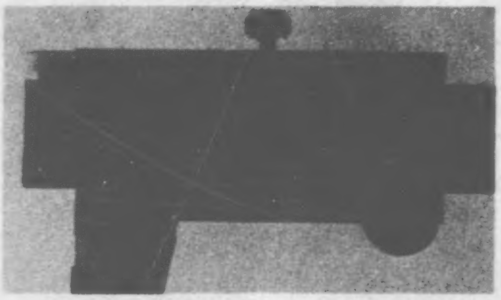
d. ____________________



e. ____________________



f. ____________________



g. ____________________

h. ____________________

i. ____________________

8. Demonstrate the ability to:
   - a. Use vernier caliper to take inside, outside, and depth measurements.
   - b. Use the depth vernier.
   - c. Use the vernier height gage for layout and inspection.
   - d. Use the universal bevel protractor to measure angles.

   (NOTE: If the above activities have not been finished before the test, ask your instructor when they should be completed.)

VERNIER MEASURING TOOLS
UNIT V

ANSWERS TO TEST

(NOTE: The point system designated in parentheses is intended to be a guideline and should be adapted as needed. The point total is 300.)

1. (16 points)

   a. 4
   b. 8
   c. 2
   d. 9
   e. 1
   f. 3
   g. 11
   h. 6
   i. 5
   j. 7
   k. 12
   l. 10

2. (5 points)

   a. Universal vernier caliper
   b. Universal bevel protractor
   c. Vernier depth gage
   d. Vernier height gage
   e. Standard vernier caliper

3. (30 points)

   a. Clamp screws
   b. Vernier slide
   c. Nibs
   d. Graduated beam
   e. Fine adjusting screw
   f. Scriber
   g. Dial
   h. Blade
   i. Stock
   j. Depth blade
   k. Inside jaws
   l. Vernier plate
   m. Outside jaws
   n. Vernier plate
   o. Base

4. (8 points)

   a. Main scale--Is divided into units and sub-units

   b. Vernier scale--Divides the sub-units into parts of sub-units

   c. Vernier slide--Carries the vernier scale up and down the main scale; it can be adjusted with the fine adjusting screw and locked in place with the locking screw

   d. The reading-Is obtained by combining the readings of the two scales

5. (24 points)

a.	1	d.	1	g.	4	j.	1 or 4
b.	4	e.	2	h.	3	k.	1
c.	1	f.	1	i.	2		

6. (12 points)

   a. Always keep vernier measuring tools free of dirt, grease, and other foreign matter; lay on clean shop towel, never directly on metal surface

   b. After using, wipe with clean soft rag and apply a thin coat of light oil

   c. Never throw these tools around; handle them carefully so they will maintain their accuracy for years

   d. Make sure the lock screws are loosened before attempting to move the sliding jaw

   e. Do not try to force a reading; it is easy to spring the jaws, causing the tool to lose its accuracy

   f. Examine the vernier and check it with a standard to ensure accuracy

7. (45 points)

a.	1.561	d.	5.378	g.	4.821
b.	2.156	e.	2.017	h.	5.597
c.	0.250	f.	3.375	i.	3.118

8. Performance skills evaluated to satisfaction of instructor (160 points)

DIAL INDICATORS
UNIT VI

UNIT OBJECTIVE

After completion of this unit, the student should be able to use dial indicators for alignment and referencing. This knowledge will be shown by completion of assignment sheet, job sheets, and unit test with a minimum score of 85 percent accuracy.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with dial indicators to the correct definitions.
2. Identify different types of indicators.
3. Select the proper type of indicator to do work required.
4. State the rules for proper care of dial indicators.
5. Demonstrate the ability to:
    a. Align a vise.
    b. Align work in 4-jaw chuck with dial indicator.
    c. Align work clamped to angle plate parallel to surface plate.
    d. Align the head of a ram and turret mill.
    e. Reference the spindle to the solid jaw of a vise.
    f. Use dial indicator to check hole locations.
    g. Use dial indicator to center rotary table.
    h. Use dial indicator to align tailstock of lathe.

DIAL INDICATORS
UNIT VI

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

   A. Provide students with objective sheet and make transparencies.

   B. Provide students with information and assignment sheets.

   C. Discuss unit and specific objectives.

   D. Discuss information and assignment sheets.

   E. Demonstrate and discuss procedures outlined in job sheets.

   F. Demonstrate other uses of dial indicators.

   G. If possible, have advanced student pre-make parts to be used by students in this unit (Figures 1 and 2).

   (NOTE: See Job Sheet #3.)

FIGURE 1

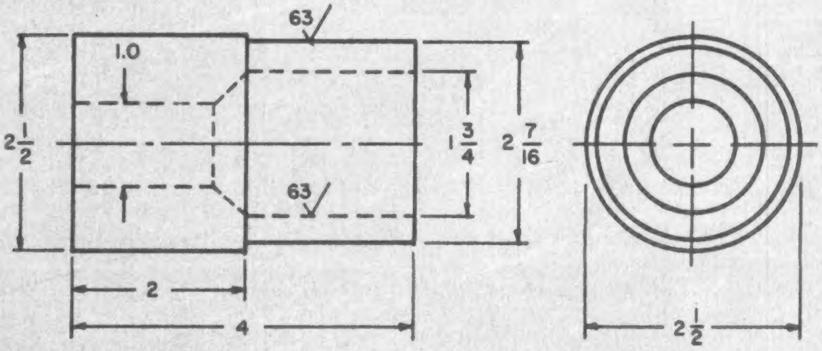
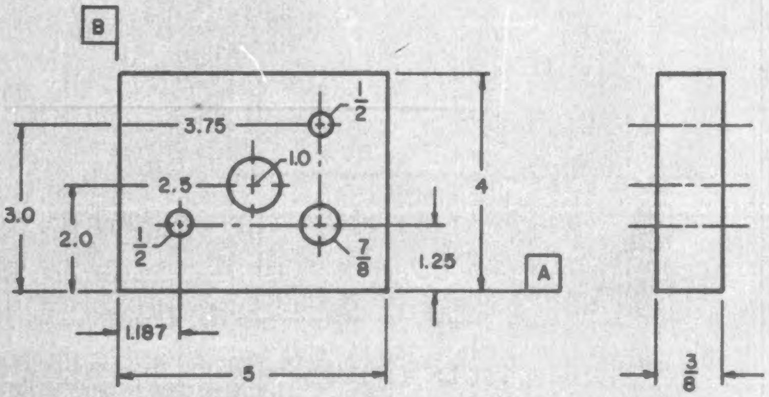

63
1.0
2 1/2
1 3/4
2 7/16
63
2
4
2 1/2

FIGURE 2


B
3.75
1/2
1.0
2.5
4
3.0
2.0
1/2
7/8
1.25
A
1.187
5
3/8

H. Stress trade techniques that vary from factory to factory.

I. Give test.

J. Reteach and retest, if necessary.

II. Instructional materials:

A. Objective sheet

B. Information sheet

C. Transparency masters

1. TM #1--Attachments Used with Dial Test Indicators
2. TM #2--Attachments Used with Plunger Back Dial Indicator
3. TM #3--Magnetic Base Indicator Holders

D. Assignment Sheet #1--Select the Proper Indicator to do Work Required

E. Answers to Assignment Sheet #1

F. Job sheets

1. Job Sheet #1--Align a Vise
2. Job Sheet #2--Align Work in 4-Jaw Chuck with Dial Indicator
3. Job Sheet #3--Align Work Clamped to Angle Plate Parallel to Surface Plate
4. Job Sheet #4--Align the Head of a Ram and Turret Mill
5. Job Sheet #5--Reference the Spindle to the Solid Jaw of a Vise
6. Job Sheet #6--Use Dial Indicator to Check Hole Locations
7. Job Sheet #7--Use Dial Indicator to Center Rotary Table
8. Job Sheet #8--Use Dial Indicator to Align Tailstock of Lathe

G. Test

H. Answers to test

III. Unit references:

A. *Starrett Catalog #28.* Athol, MA: The L.S. Starrett Company, 1979.

B. Brown & Sharpe Catalog #STM80. *The Shop Tool Manual.* North Kingston, RI: Brown & Sharpe Manufacturing Company.

C. Mitutoyo Catalog #3000. *Mitutoyo Measuring Instruments.* Catalog No. 3000. Paramus, NJ: MTI Corp., 1978.

DIAL INDICATORS
UNIT VI

INFORMATION SHEET

I. Terms and definitions

A. Align--To make a part or attachment true

B. Runout--The amount of movement or misalignment of a part

C. Concentric--Round surfaces which are true to each other

D. Range--The total amount of movement of a dial indicator plunger

(NOTE: Range may vary with indicators.)

E. Total indicator reading (TIR)--The difference an indicator reading will be at its maximum and minimum points

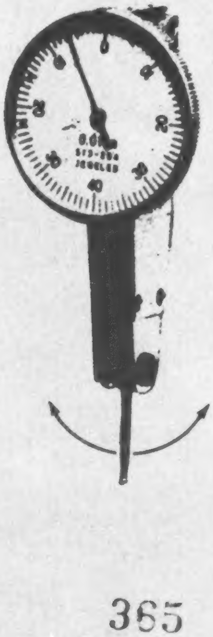
F. Dings--Irregularities on a surface caused by abuse

II. Types of indicators

(NOTE: All indicators are mechanical motion amplifying devices enabling the worker to detect small amounts of movement.)

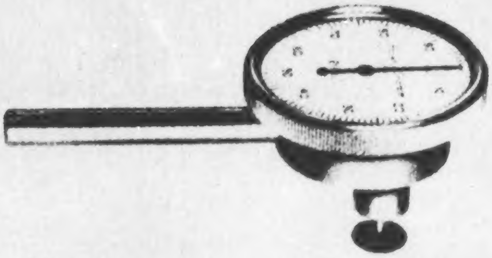
A. Dial test indicator (Transparency 1)

(NOTE: This indicator is the one most frequently used.)



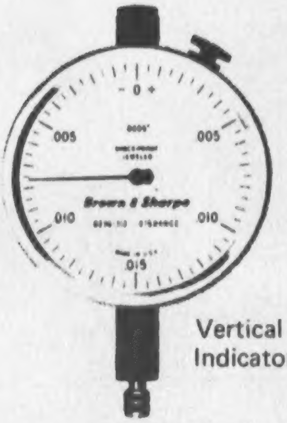
INFORMATION SHEET

B. Plunger back dial indicator (Transparency 2)

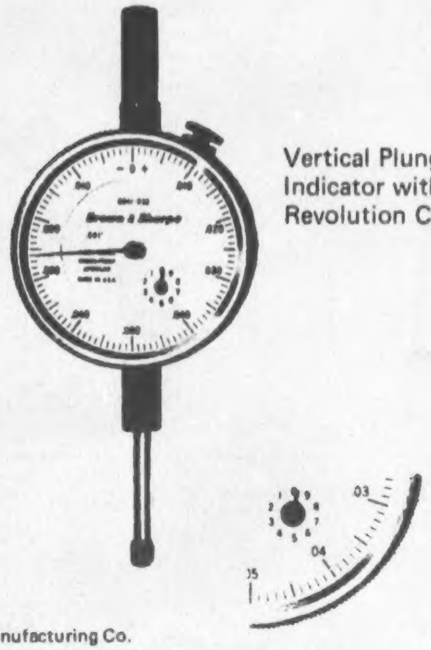


Used with permission of Brown & Sharpe Manufacturing Co.

C. Vertical plunger dial indicators(Transparency 3)


- 0 +
.005
.005
Brown & Sharpe
.010
.010
.015

Vertical Plunger Indicator


- 0 +
Brown & Sharpe
.03
.04

Vertical Plunger Indicator with Revolution Counter

Used with permission of Brown & Sharpe Manufacturing Co.

INFORMATION SHEET

D. Junior test indicator

Used with permission of The L. S. Starrett Company

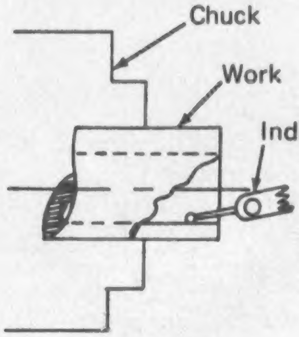
III. Selecting the proper type of indicator (Assignment Sheet #1)

A. Junior test indicator--Used to align parts inside or outside when held in a lathe chuck; also used to align a vise; used when learning to use a dial indicator

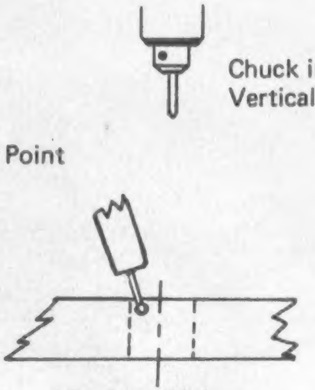
(NOTE: This type of indicator is not accurate to more than 0.002 tolerance.)

B. Dial test indicator--Used in small places such as indicating on a hole or a bore; also used with height gage for inspection; used to align work true to spindle of lathe

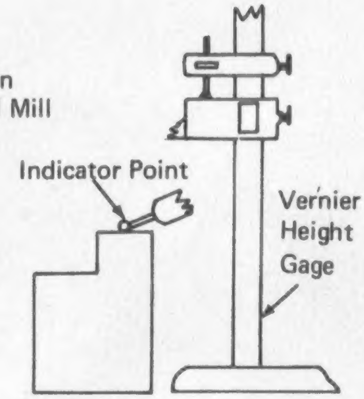
Examples:


Chuck
Work
Indicator Point

Aligning a Bore True to Spindle of Lathe


Chuck in Vertical Mill

Aligning a Hole on Mill True to Spindle

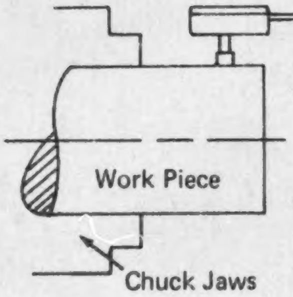

Indicator Point
Vernier Height Gage

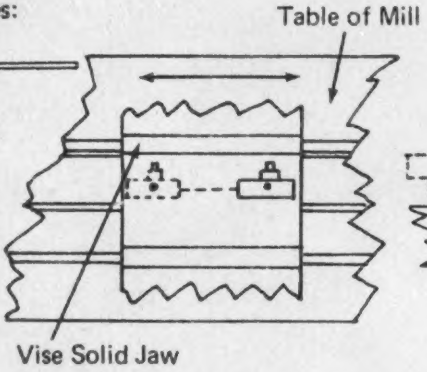
Inspection of Parts

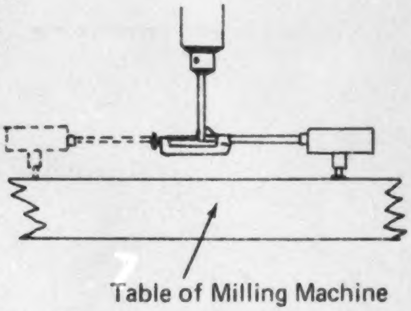
INFORMATION SHEET

C. Plunger back dial indicator--Used to align work true to spindle of lathe, align vises, or align head of ram and turret mill perpendicular to table

Examples:

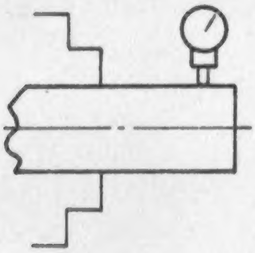




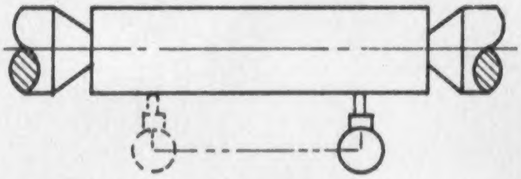


D. Vertical plunger dial indicator--Used to align lathe tailstock, vertical head of mill, or work in lathe; can also be mounted to comparator, snap gages, thickness gages, or other fixtures for special applications

Examples:



Aligning the Work or
Checking for Concentricity



Aligning Tailstock
True or Setting Tapers

(NOTE: Indicators have a variety of applications and in grinding they may run on work all the time.)

IV. Care of dial indicators

A. Cleanliness--Keep the indicator stored in a box free of dirt and grease; otherwise the spindle has a tendency to stick, giving you a bad reading

B. Vibration--Do not hammer on objects with indicator point in contact with work or you can damage the indicator

C. Lubrication--Never lubricate dial indicators; this causes them to become sluggish

D. Handling--Always handle with care and check secureness of setup so the indicator will not fall

INFORMATION SHEET

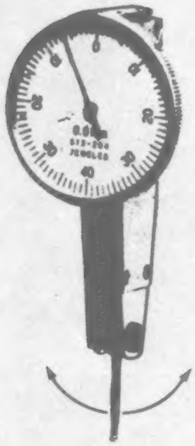
E. Inspection--Inspect the indicator by mounting it on a comparator stand and using a gage block to see if the spindle moves the correct amount

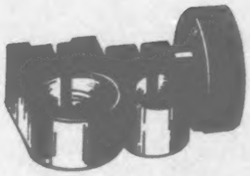
F. While work is turning--It is not a good practice to use machine power to turn work while point is in contact with work; it causes a flat on the point of the indicator

G. Revolving the indicator--Use hand power, never machine power, to revolve the indicator

H. Exceeding the range--Never exceed the range of the indicator because it will damage it

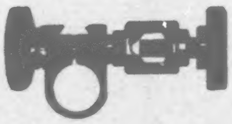
Attachments Used with Dial Test Indicators



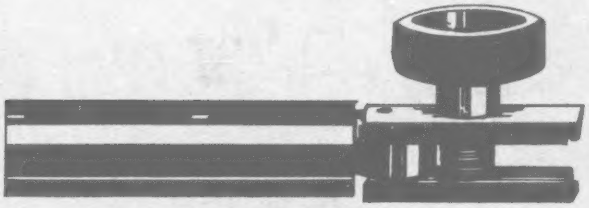


Swivel Clamp

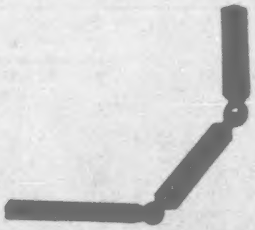
Rectangular Bar



Universal Swivel Clamp



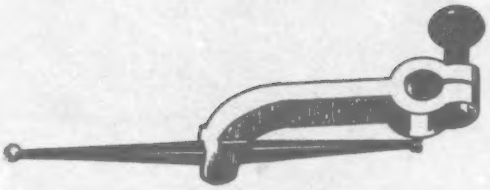
Swivel Support



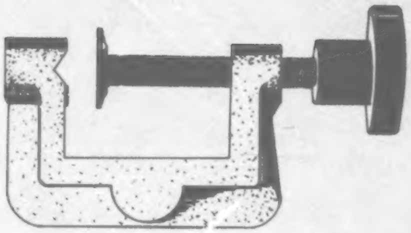
Double Jointed Attachment

Universal Dovetail Attachment

Attachments Used with Plunger Back Dial Indicator

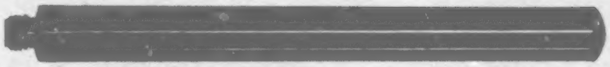


Hole Attachment

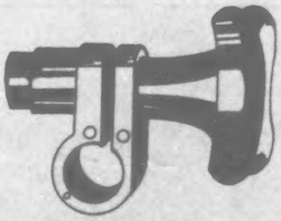


Clamp

Toolpost Holder

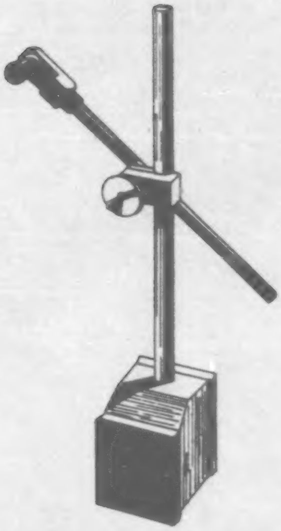


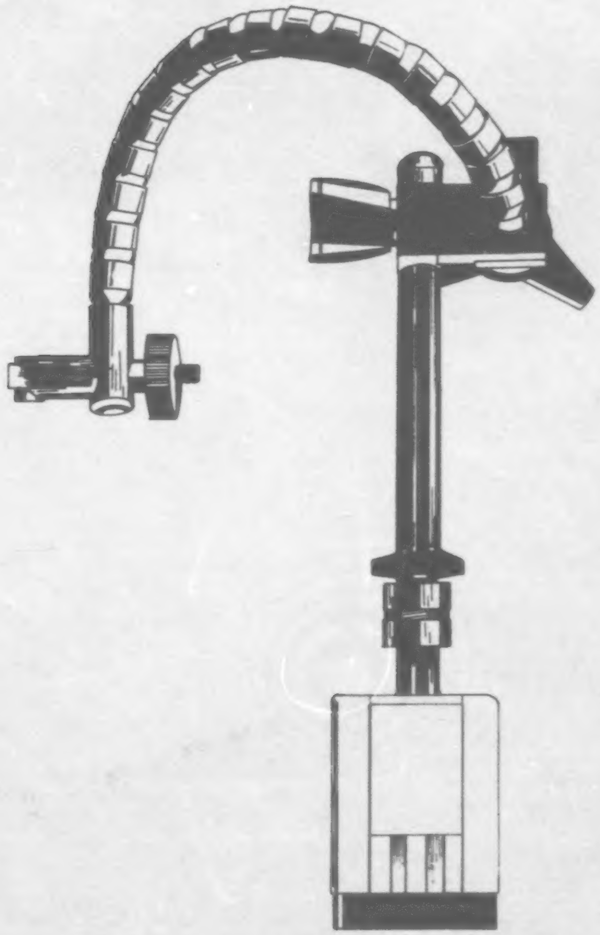
Upright Spindle



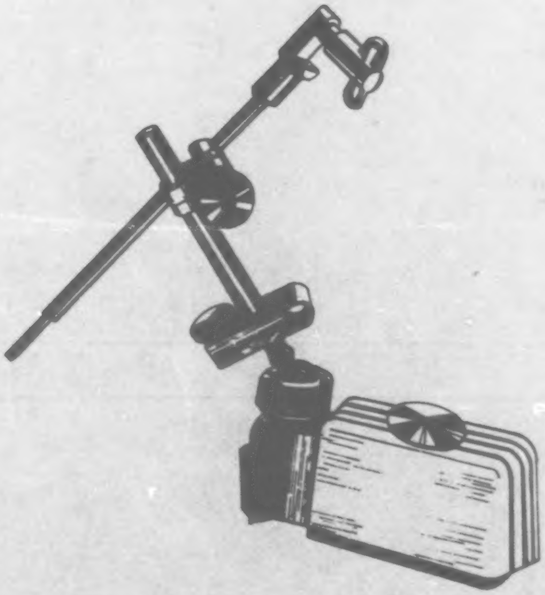
Universal Clamp

Magnetic Base Indicator Holders





General Purpose Flexbar Holder
Magnetic Base



DIAL INDICATORS
UNIT VI

ASSIGNMENT SHEET #1--SELECT THE PROPER INDICATOR TO DO WORK REQUIRED

NAME ______________________________ SCORE ______________

Knowing the proper indicator to use makes the job easier and usually more accurate.

Select the best type of indicator to do the job described. Write the correct numbers in the blanks provided.

1. Junior test indicator
2. Dial test indicator
3. Plunger back dial indicator
4. Vertical plunger dial indicator

_____a. Used to align a tailstock of a lathe true to the headstock

_____b. Used to align work chucked in 4-jaw chuck true to the spindle of the lathe

_____c. Used to inspect parts when mounted on a height gage

_____d. Used to align a vise mounted on a milling machine table

_____e. Used to indicate the inside diameter of a part chucked in the lathe

_____f. Used to align or sweep the head of a ram and turret milling machine in true to the table

_____g. Used to align a part when you are learning to use indicators

_____h. Used to align the spindle of a milling machine true to the center of a rotary table

_____i. Used to check hole location

_____j. Used to check the setting of a taper attachment

DIAL INDICATORS
UNIT VI

ANSWERS TO ASSIGNMENT SHEET #1

a. 4

b. 3 or 4

c. 2

d. 3

e. 2

f. 3 or 4

g. 1

h. 2

i. 2

j. 4 or 3

DIAL INDICATORS
UNIT VI

JOB SHEET #1--ALIGN A VISE

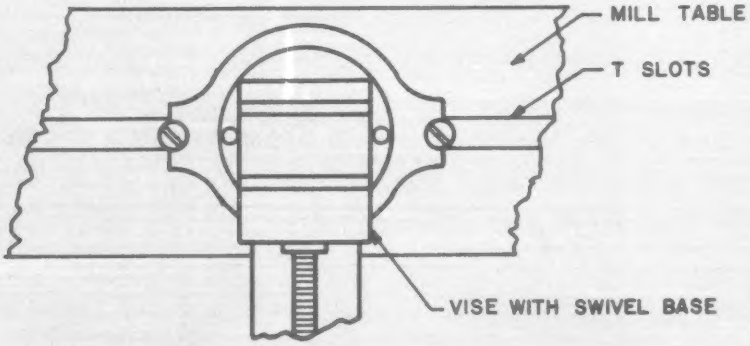
I. Tools and equipment

- A. Plunger back dial indicator
- B. Vise with swivel base
- C. T-bolts and nuts to mount vise
- D. Wrench to fit nut
- E. Vertical or horizontal milling machine with arbor or drill chuck
- F. Rubber, plastic, or lead mallet

II. Procedure

- A. Wipe off the table of the milling machine with a rag and check for dings by running hand over surface of mill table
- B. Wipe off bottom of vise and set on mill table
- C. Put T-bolts in table and slide into slots of swivel base and secure
- D. Turn vise so jaws are parallel to feed of table (longitudinally) (Figure 1)

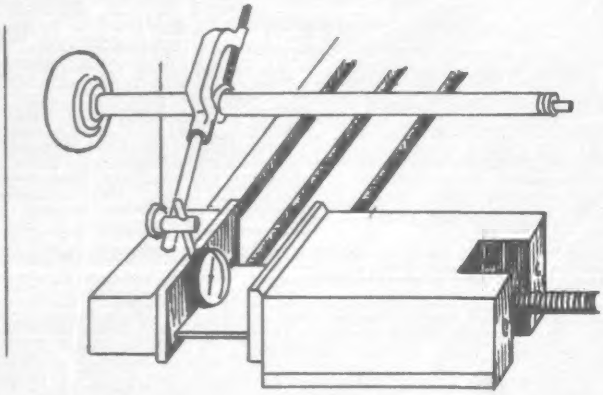
FIGURE 1



JOB SHEET #1

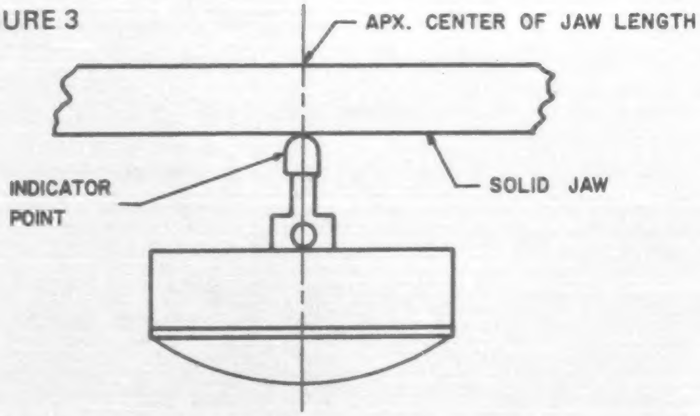
E. Secure indicator to arbor with clamp (Figure 2)

FIGURE 2



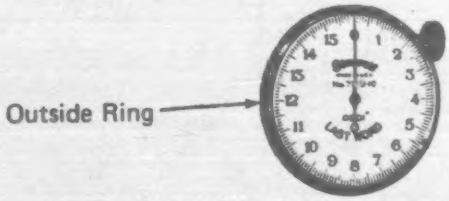
F. Move table so indicator is in center of solid jaw and move the transversal feed (in and out) until the solid jaw makes contact with the point of the indicator spindle (Figure 3)

FIGURE 3


APX. CENTER OF JAW LENGTH
INDICATOR POINT
SOLID JAW

G. Set indicator at zero by turning the outside ring to the right or left so the indicator needle points to zero (Figure 4)

FIGURE 4

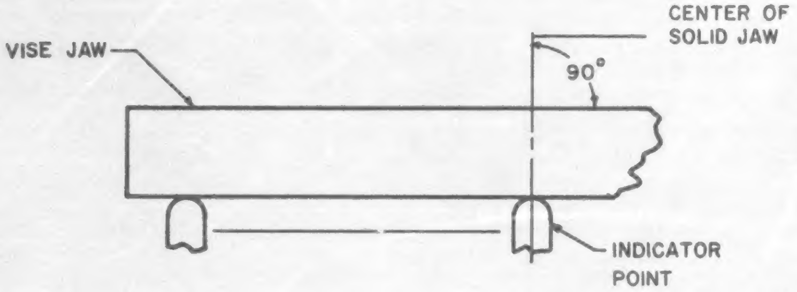

Outside Ring
15
1
2
3
4
5
6
7
8
9
10
11
12
13
14
LAST WORD

Used with permission of The L. S. Starrett Company

JOB SHEET #1

H. Crank the hand wheel so it moves the table until the indicator point is at one side of the vise jaw (Figure 5)

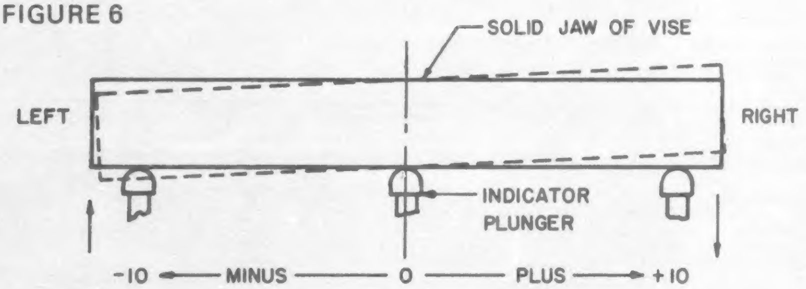
FIGURE 5

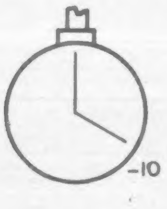

VISE JAW
CENTER OF SOLID JAW
90°
INDICATOR POINT

(CAUTION: Do not crank the indicator off the vise jaw.)

I. Examine the difference; did the needle move plus or minus and how much? (Figure 6)

FIGURE 6


SOLID JAW OF VISE
LEFT
RIGHT
INDICATOR PLUNGER
-10
MINUS
0
PLUS
+10



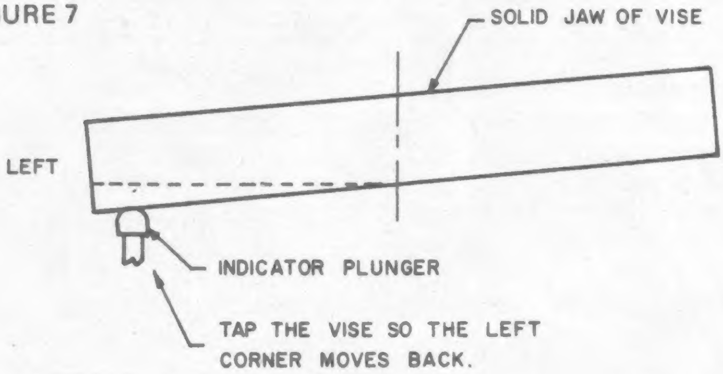
THE NEEDLE MOVED FROM 0 TO -10 WHEN TABLE OF MILL IS MOVED TO THE RIGHT OR LEFT EDGE OF THE VISE.

(NOTE: If you had traveled to the right edge the needle would have been + 10; therefore the total difference from right to left side is +.020.)

JOB SHEET #1

J. With the point still in contact with the left side of the solid jaw, tap the solid jaw of the vise with a soft mallet until the needle is at "0" (Figure 7)

FIGURE 7



(NOTE: Make sure that the two screws holding the vise to the rotary base are snug and the two T-Bolts that secure the rotary base to the mill table are tight.)

K. Crank the table back to center of jaw, rezero the indicator, and crank it back to the left side (Figure 7)

  1. If it does not read "0" - "0" and the needle is still on the plus (+) side, tap back of vise to zero and recheck alignment
  2. If needle moves to (-) minus side of zero when you are on the left of the jaw, you went too far; tap back of jaw to right approximately half the way to zero
  3. Move indicator point back to center of vise, zero indicator, and recheck
  4. Continue this until solid jaw reads "0" - "0"

L. Tighten the nuts that secure the vise to the swivel base by snugging right, then left; continue this until nuts are tight

M. Check alignment of vise jaw one more time to make sure the vise did not move while you were tightening

DIAL INDICATORS
UNIT VI

JOB SHEET #2--ALIGN WORK IN 4-JAW CHUCK WITH DIAL INDICATOR

I. Tools and equipment

  A. Plunger type dial indicator

  B. Swivel point dial test indicator

  C. Magnet base indicator holder

  D. Lathe with 4-jaw chuck mounted and chuck wrench

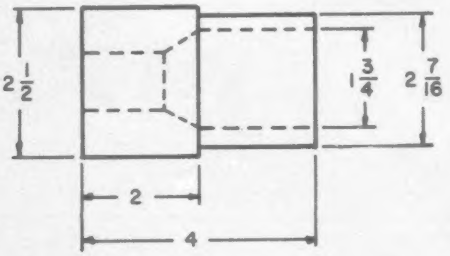
  E. 6" steel rule

II. Materials

  A. Chalk or pencil

  B. Machined steel bar (Figure 1)

FIGURE 1



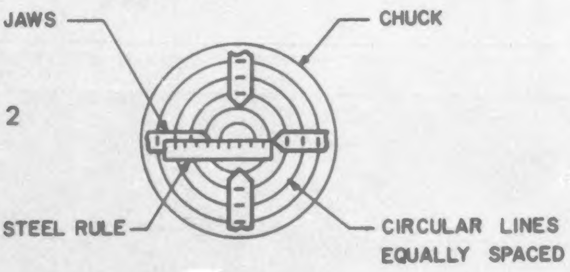
$2\frac{1}{2}$
$1\frac{3}{4}$
$2\frac{7}{16}$
2
4

III. Procedure for aligning outside circumference

  A. Open jaws of chuck to approximately the diameter and insert round steel part (Figure 2)

  (NOTE: Use 6" steel rule and circular lines on face of chuck when opening jaws.)

FIGURE 2



JAWS
CHUCK
STEEL RULE
CIRCULAR LINES
EQUALLY SPACED

JOB SHEET #2

B. Snug the jaws down on part by tightening the two jaws 90° to each other, just enough to hold part secure

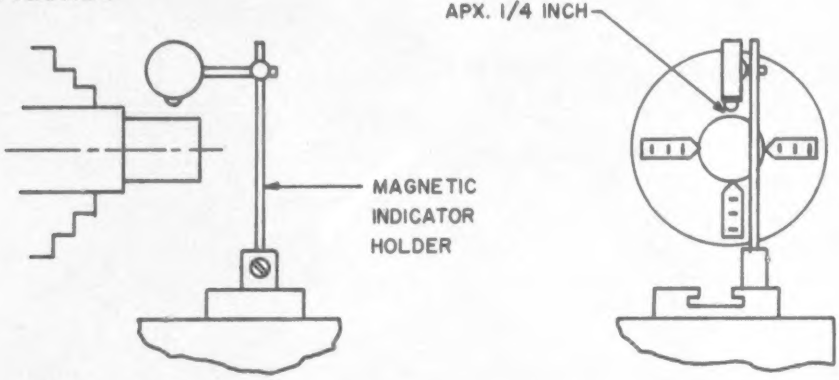
C. Put lathe in neutral or release belt tension so chuck can be turned by hand

D. Mount indicator to magnetic base

E. Put magnetic base on cross slide or compound and check to see if it is secured by the magnet

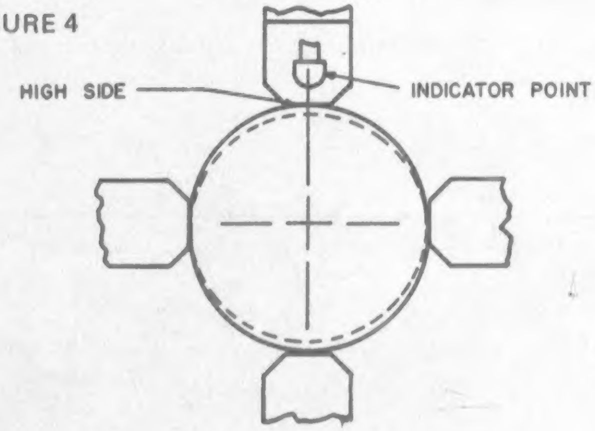
F. Move carriage toward headstock until indicator is over work, but not touching work (Figure 3)

FIGURE 3


APX. 1/4 INCH
MAGNETIC
INDICATOR
HOLDER

G. Rotate the work by hand until you have the high side or the side that is closest to the indicator point up and at one of the jaws (Figure 4)

FIGURE 4


HIGH SIDE
INDICATOR POINT

JOB SHEET #2

H. Use chalk or a pencil and mark high side; loosen jaw opposite the high side and tighten high side just a little, then retighten adjusting screw on low side

(NOTE: Always work with opposite jaws, 1 and 3, or 2 and 4.)

I. Wipe off pencil mark and turn the part while holding pencil close to work; keep turning and move pencil forward slowly to find new high point

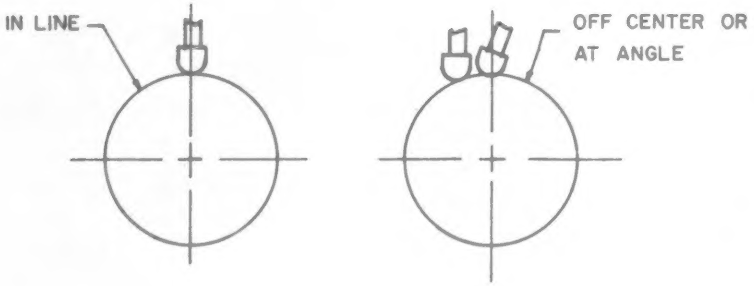
J. Loosen screw on low side and tighten new high side

K. Check with pencil again; if pencil marks work approximately 3/4 way around circumference, you are now ready to use indicator; if not, continue to adjust until mark is made on approximately 3/4 of circumference

L. Move indicator down until the point is touching the work; then turn the crossfeed handwheel, moving the indicator back and forth over the work; when indicator needle is at its maximum reading, stop and adjust dial to read zero (Figure 5)

(NOTE: The straighter the indicator plunger is to the work, the less error you will have.)

FIGURE 5



M. Turn work and note the difference; loosen screw on low side and tighten high side, shifting part approximately half the difference

N. Continue this process until the needle of the indicator has no movement

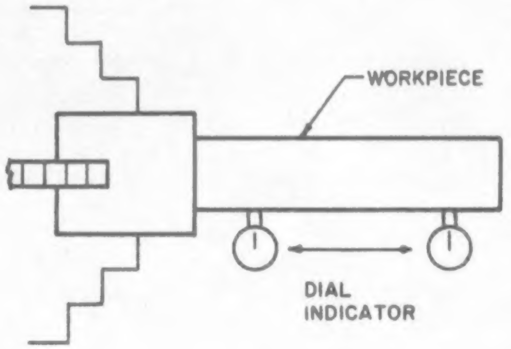
(NOTE: When there is only 0.003 or 0.004 difference, you can usually just tighten the high side half the difference.)

(CAUTION: Work with opposite jaws; never loosen adjoining jaws or the part will fall out.)

JOB SHEET #2

O. When indicating a part that is long, first set the part straight with the lathe by indicating the length of the part at adjoining jaws; then indicate the part true to the spindle (Figure 6)

FIGURE 6


WORKPIECE
DIAL INDICATOR

IV. Procedure for aligning inside diameter (bore)

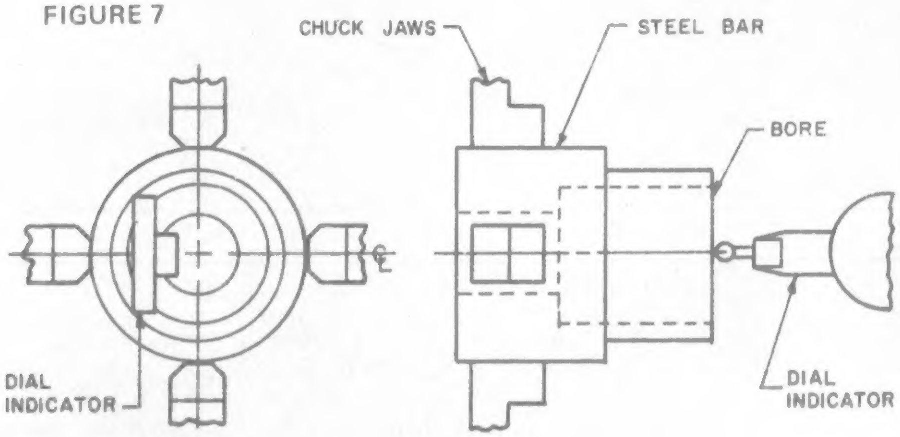
A. Mount steel bar with bored end exposed in 4-jaw chuck (Figure 7)

B. Mount dial test indicator to magnet base

C. Turn the indicator so the dial face is vertical, making the movement of the indicator point horizontal

D. Adjust the indicator so point is on center (Figure 7)

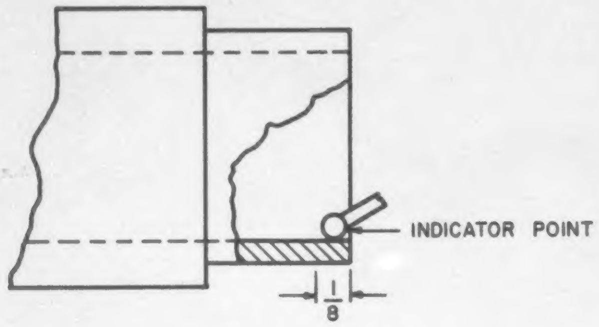
FIGURE 7


CHUCK JAWS
STEEL BAR
BORE
℄
DIAL INDICATOR
DIAL INDICATOR

JOB SHEET #2

E. Adjust the crossfeed and longitudinal feed of the lathe until the point of the indicator is in bore approximately 1/8" and near inside wall of bore (Figure 8)

FIGURE 8


INDICATOR POINT
1/8

F. Put the lathe in neutral and rotate the chuck slowly until you have found the greatest point of movement of the indicator needle

G. Rotate the chuck to the nearest jaw so the jaw is horizontal; then turn the dial so the needle is on "O"

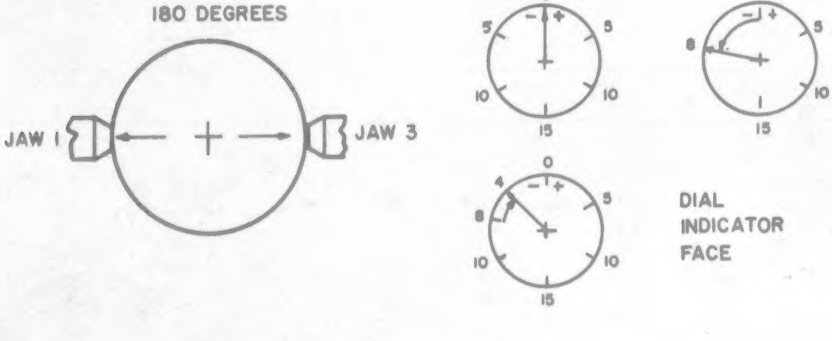
H. Rotate the chuck 180° and note the difference

I. Loosen the high side and tighten the low side until the needle has moved 1/2 the difference; retighten the high side (Figure 9)

J. Repeat this until the indicator is at the same point when chuck is turned 180° (Figure 9)

(NOTE: Work only with opposite jaws.)

FIGURE 9


180 DEGREES
JAW 1
JAW 3
0
5
5
10
10
15
0
8
5
10
15
0
4
8
5
10
10
15
DIAL
INDICATOR
FACE

JOB SHEET #2

K. Repeat steps G-J with the next set of jaws, working them in the same manner until the indicator needle reads the same at each jaw

L. Check whole part again to make sure that the dial indicator remains at "0" when needle is turned 360°

DIAL INDICATORS
UNIT VI

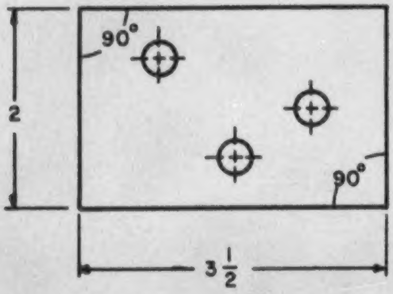
JOB SHEET #3--ALIGN WORK CLAMPED TO ANGLE PLATE PARALLEL TO SURFACE PLATE

I. Tools and equipment

- A. Swivel point dial test indicator
- B. 6" steel rule
- C. 4" angle plate
- D. 12" x 18" surface plate
- E. 2 small C-clamps (2 1/2") or parallel clamps
- F. Height gage or surface gage
- G. Small mallet
- H. Adjustable parallel

II. Material--Ground plate 1/2" x 2" x 3 1/2", pre-machined (Figure 1)

FIGURE 1



← SKETCH IN SUGGESTED ACTIVITIES

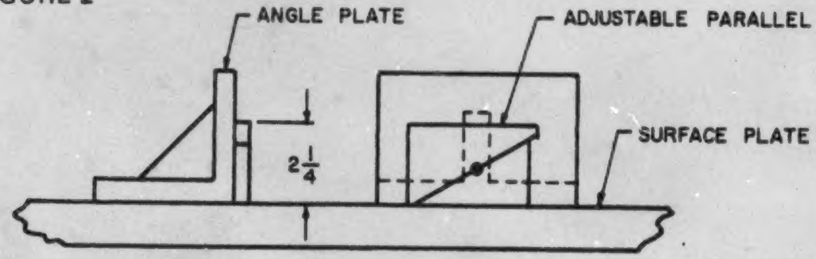
III. Procedure

- A. Clean off surface plate and angle plate with clean rag
- B. Set angle plate on surface plate
- C. Loosen screws of adjustable parallel and adjust parallel to 2 1/4"; tighten screws

JOB SHEET #3

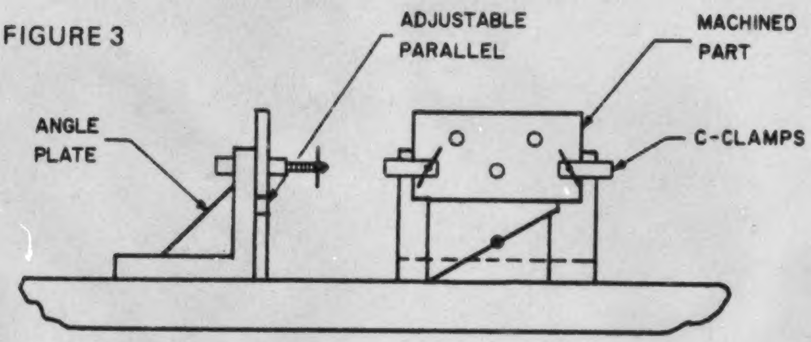
D. Set parallel on surface plate next to angle plate (Figure 2)

FIGURE 2


ANGLE PLATE
ADJUSTABLE PARALLEL
SURFACE PLATE
$2\frac{1}{4}$

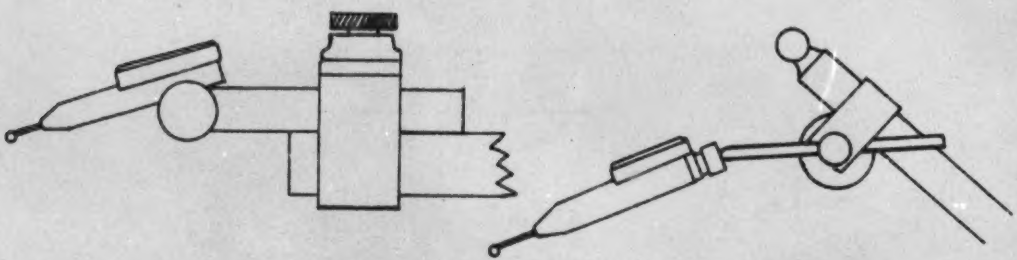
E. Set part to be aligned on parallel and clamp (Figure 3)

FIGURE 3


ADJUSTABLE PARALLEL
MACHINED PART
ANGLE PLATE
C-CLAMPS

F. Mount indicator to height gage on surface gage (Figure 4)

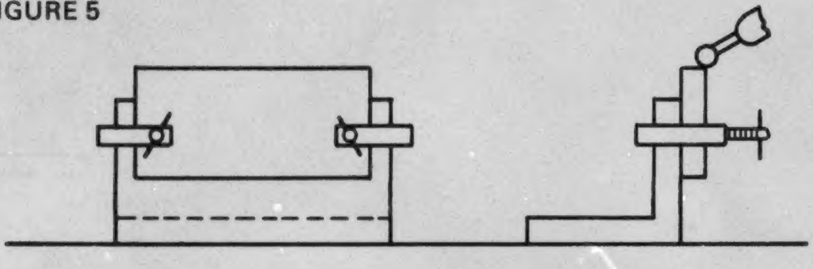
FIGURE 4



JOB SHEET #3

G. Move the point of the indicator over the edge of the part and use the adjusting screw to zero the point on the part at one end (Figure 5)

FIGURE 5



H. Move the indicator from one end to the other end of the part; if the dial does not stay on zero, the part is not parallel to the surface plate

I. Loosen one clamp and gently tap the part up or down and recheck

J. After you get the dial to read "0" end to end, tighten the clamps and recheck to make sure the part did not move when you tightened the clamps

(NOTE: This operation may be necessary when you are laying out, inspecting, or machining.)

DIAL INDICATORS
UNIT VI

JOB SHEET #4--ALIGN THE HEAD OF A RAM AND TURRET MILL

I. Tools and equipment

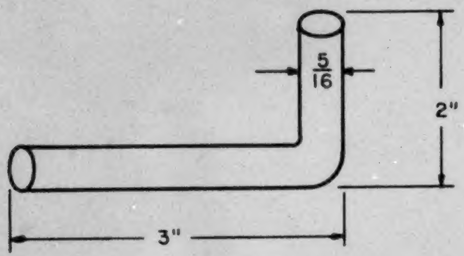
A. Turret milling machine

B. Wrenches to fit head bolts

C. Plunger back dial indicator with swivel and clamp

D. 5/16" or 3/8" bent steel bar (See Figure 1)

FIGURE 1



II. Procedure

(NOTE: Procedures will vary with different machines. This job sheet outlines procedures for a Bridgeport ram and turret mill.)

(CAUTION: Read safety information at end of job sheet before starting this job sheet.)

SAFETY INFORMATION

To prevent serious bodily injury, you should observe the following basic safety precautions when installing, operating or servicing your Bridgeport milling machine.

1. Follow all instructions in the machine manual.
2. Wear approved industrial safety glasses and safety shoes.
3. *Do not* wear gloves, long sleeves, long hair, rings, watches, jewelry or other loose items that could become caught in moving parts.
4. Keep all parts of your body away from moving parts (belts, cutters, gears, etc.)
5. Use proper point of operation safeguarding.

JOB SHEET #4

These and other safety precautions are discussed in the American National Standards Institute Standard entitled *Safety Requirements for the Construction, Care, and Use of Drilling, Milling, and Boring Machines* (ANSI B11.8-1974).

This publication is available from: The American National Standards Institute
1430 Broadway
New York, New York 10018

Safeguarding for protection at the point of operation can only be designed and constructed when the parameters of the particular operation have been determined. As a result, ANSI B11.8-1974, Section 5.1, states that *"it shall be the responsibility of the employer to provide, and ensure the use of, a guard, guarding device, awareness barrier, awareness device, or shield ..."*

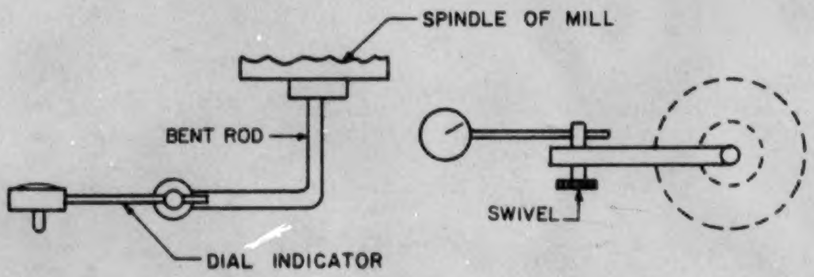
To assist machine users in designing point of operation safeguarding for their specific machine applications, the Occupational Safety and Health Administration has published a booklet entitled *Concepts and Techniques of Machine Safeguarding* (O.S.H.A. Publication Number 3067).

This publication is available from: The Publication Office--O.S.H.A.
U.S. Department of Labor
200 Constitution Avenue, NW
Washington, D.C. 20210

A. Center the spindle approximately in the center of the table

B. Mount the bent rod in the spindle of the mill and then use a swivel and mount the indicator to the bent rod (Figure 2)

FIGURE 2



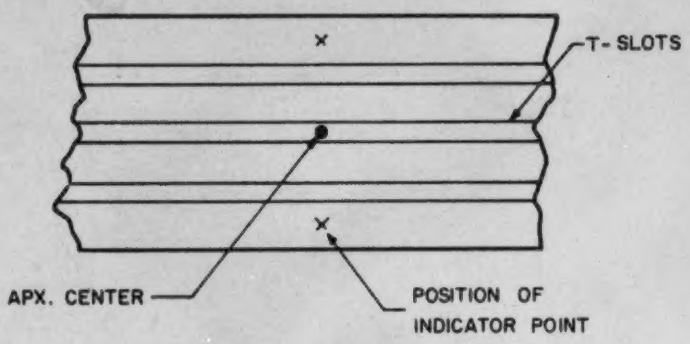
C. Put the spindle in neutral so the indicator can be rotated by hand without resistance from the gears or drive

D. Lower the quill approximately 3", raise the knee of mill short of making contact with indicator point and table; then engage both knee and table locks

JOB SHEET #4

E. Adjust the position of the indicator point so that when rotated it will be on a surface of the table of the mill; then retract quill (Figure 3)

FIGURE 3



F. Check the graduations on the head; if they are not on (0°), loosen the nuts and set the head at zero

(NOTE: Even though the head appears to be on zero you cannot set it accurately with these marks. To be 90° to the plane of the table the head must be indicated in.)

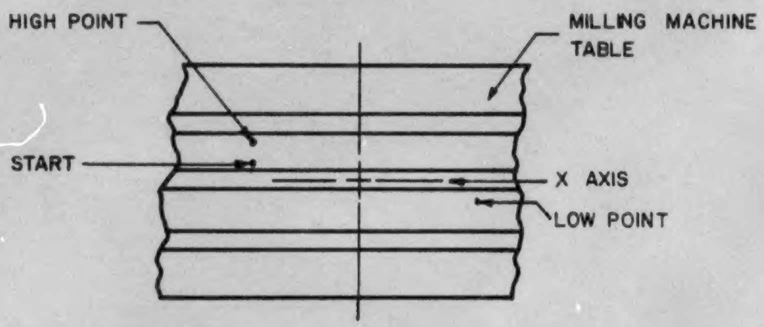
G. Bring the quill down, and adjust indicator so the plunger of the indicator is in contact with the table; then rotate the spindle slowly in a complete circle to find the highest point with the indicator

(NOTE: Use a plastic card under the indicator point when you are rotating the indicator over the T-slots. The plastic card keeps the indicator point from dropping into the slot and moving or damaging the indicator; however, the card MUST be removed when taking readings. If a .030 thousandths travel "last word" indicator is used, do not set at more than .005 or .007 [thousandths] for readings. A plastic card thickness could easily "kick" the indicator beyond its travel limit and cause inaccurate readings.)

JOB SHEET #4

H. Note the indicator high and low points on the table in the X axis (longitudinally), starting from the 90° point closest to the indicator's high point reading on X axis (Figure 4)

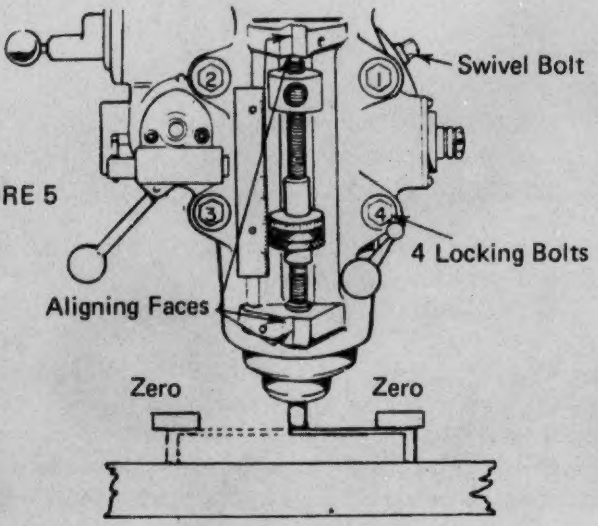
FIGURE 4


HIGH POINT
MILLING MACHINE TABLE
START
X AXIS
LOW POINT

I. Adjust the quill up or down so indicator has about .007 load at low point; then reset indicator dial to read zero and retract the quill

J. Loosen the four (4) nuts or locking bolts, holding head to a light snug tightness (Figure 5)

FIGURE 5

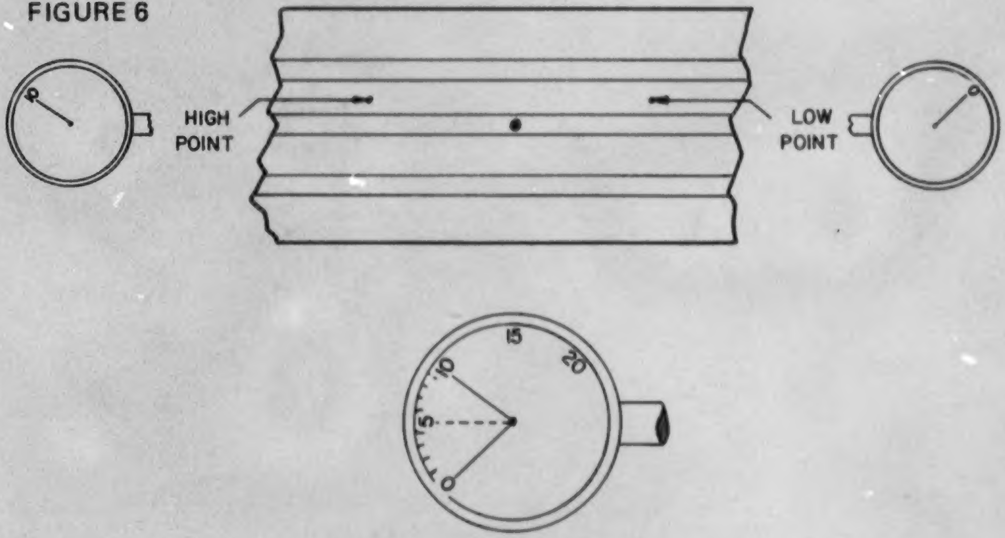

Swivel Bolt
1
2
3
4
4 Locking Bolts
Aligning Faces
Zero
Zero

Head Alignment X Axis

JOB SHEET #4

K. Bring the quill down so the dial indicator point makes contact at the low point of the X axis, then rotate the indicator to the high point; slowly move the head by turning the swivel bolt (Figure 5) until the indicator needle moves one-half the distance (Figure 6)

FIGURE 6



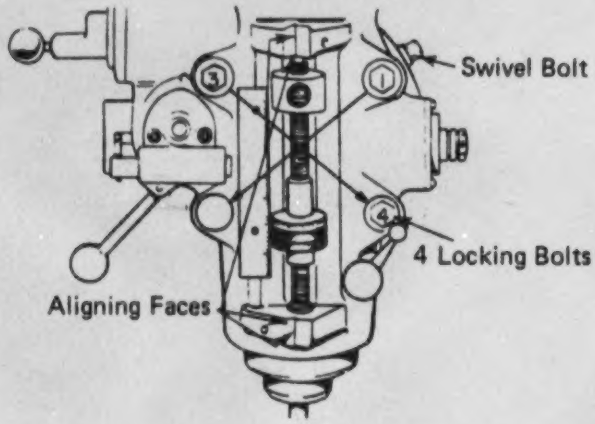
(NOTE: When rotating the indicator, slide plastic card under indicator plunger to prevent it from dropping in T-slots and possibly damaging or moving indicator; however, the card is removed when taking readings. If a .030 thousandths travel or "last word" indicator is used, do not set at more than .005 or .007 [thousandths] for readings. A plastic card thickness could easily "kick" the indicator beyond its travel limit and cause inaccurate readings.)

L. Repeat procedure and adjustments until indicator reads zero at low and high points of the X axis

JOB SHEET #4

M. Tighten the four locking bolts in sequence (1, 2, 3, 4) to about 25 ft. lbs. of pressure (Figure 7)

FIGURE 7


③
①
Swivel Bolt
④
4 Locking Bolts
Aligning Faces

N. Check with indicator to make sure the head did not move when tightening lock bolts; make corrections if necessary

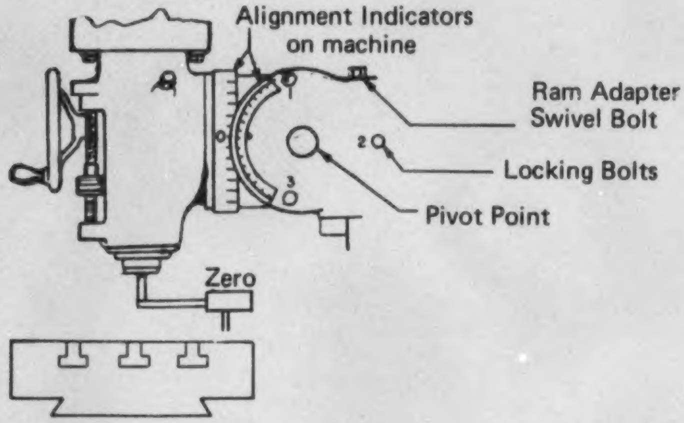
O. Tighten locking bolts in same sequence (1, 2, 3, 4) to 50 ft. lbs. pressure, no more--no less

②

JOB SHEET #4

P. Retract the quill to eliminate possible damage to the dial indicator; then loosen the three Ram Adapter locking bolts and snug back to create a drag for fine adjustment. If head moves when bolts are loosened, turn Ram Adapter swivel bolt on top of ram until indicating mark of head is on zero (Figure 8)

FIGURE 8



Head Alignment Y Axis

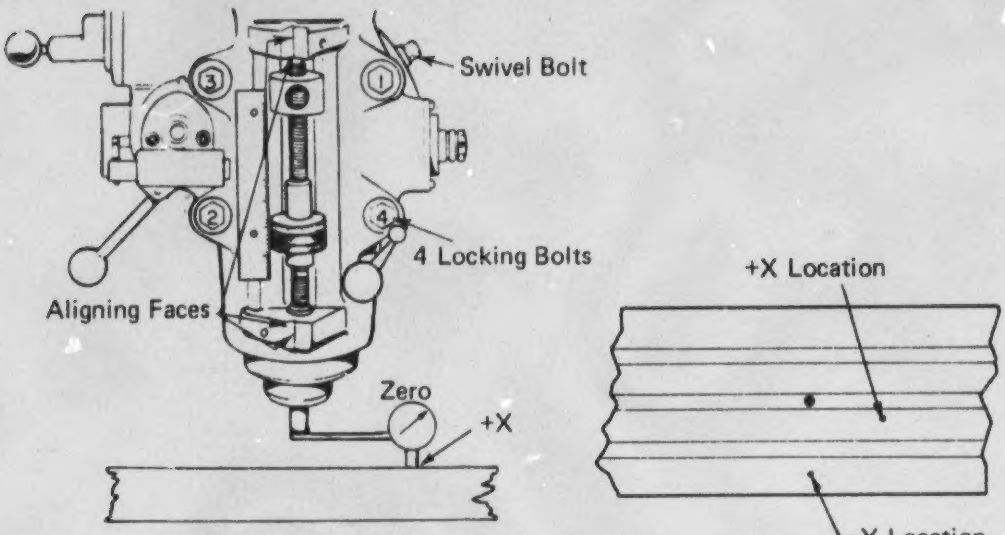
Used with permission of Bridgeport Machines Division of Textron, Inc.

Q. Loosen the three Ram Adapter locking bolts and snug back to create a drag for fine adjustment. Zero the indicator on the FRONT side and rotate the spindle 180° to the back side. If the needle went to a plus .005 on the BACK SIDE, adjust the Ram swivel bolt so indicator reading becomes plus .010 on FRONT side or add the amount the needle moved and move that much more in the same direction.

(NOTE: The table locks are still engaged. If "X" head alignment was done correctly, simply deal with the adjustments to be made in "Y" front and back.)

JOB SHEET #4

FIGURE 9

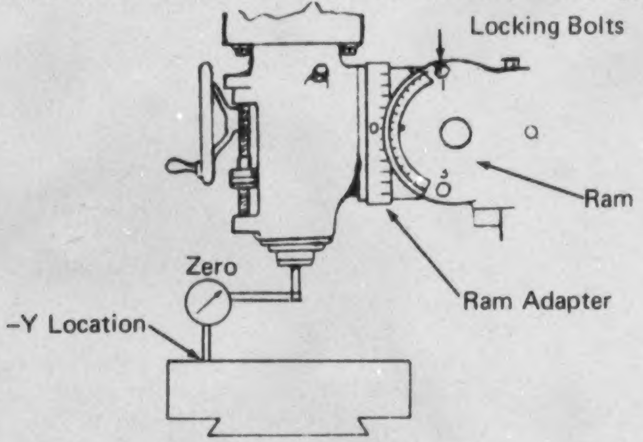

Swivel Bolt
3
1
2
4
4 Locking Bolts
Aligning Faces
Zero
+X
+X Location
-Y Location

Head Alignment X Axis

Used with permission of Bridgeport Machines Division of Textron, Inc.

R. Rotate indicator front to back and recheck; repeat procedure and adjustment until X.0005 is obtained in front and .0000 (zero) in back (Figure 10)

FIGURE 10


Locking Bolts
Ram
Zero
Ram Adapter
-Y Location

Head Alignment Y Axis

Used with permission of Bridgeport Machines Division of Textron, Inc.

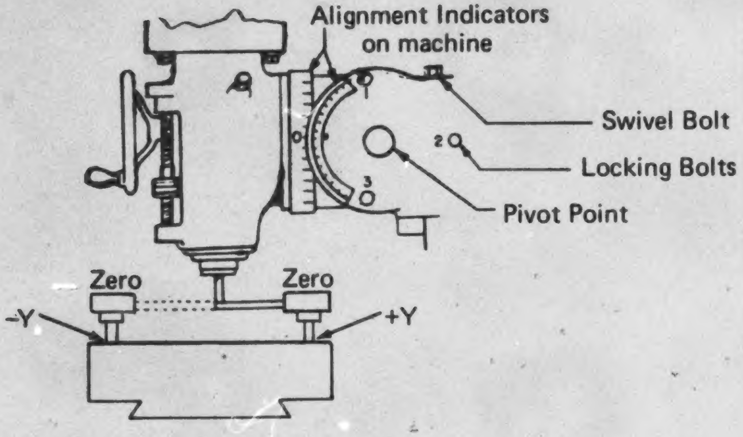
(NOTE: If "X" head alignment was done correctly, simply deal with the adjustments to be made in "Y" front and back.)

JOB SHEET #4

S. Snug locking bolts and recheck; make adjustment as above if necessary

T. Tighten locking bolts and check indicator readings at both -Y and +Y locations (Figure 11)

FIGURE 11


Alignment Indicators on machine
Swivel Bolt
Locking Bolts
Pivot Point
Zero
Zero
-Y
+Y
0
1
2
3

Head Alignment Y Axis

Used with permission of Bridgeport Machines Division of Textron, Inc.

DIAL INDICATORS
UNIT VI

JOB SHEET #5--REFERENCE THE SPINDLE TO THE SOLID JAW OF A VISE

I. Tools and equipment

   A. Vertical milling machine

   B. Last word or best test indicator with swivel or double jointed swivel

   C. Drill chuck and chuck wrench

   D. Parallel

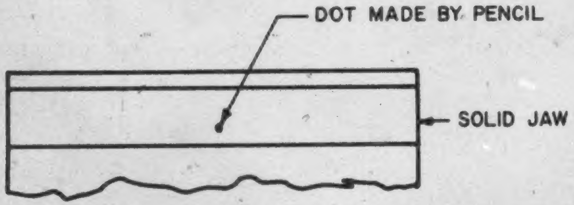
   E. Pencil

II. Procedure

   A. Insert drill chuck in spindle of mill and secure

   B. Put pencil in chuck and lower spindle until point is on jaw of vise and make mark by turning the chuck by hand (Figure 1)

FIGURE 1



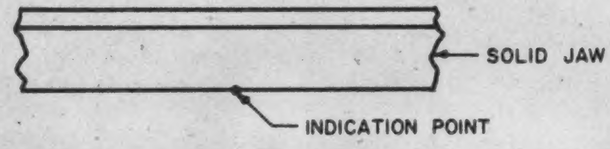
   C. Take pencil out of chuck and insert indicator holder with indicator

   D. Center the point of the indicator on dot made by pencil so when chuck is revolved the point of the indicator stays positioned on the dot

   E. Release belt tension or put spindle in neutral

   F. Move transversal feed crank so center of indicator point is centered approximately on edge of solid jaw (Figure 2)

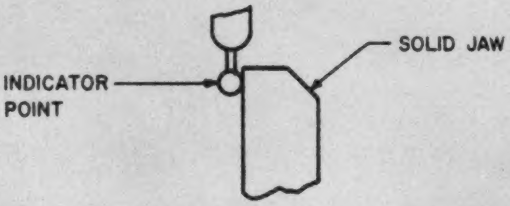
FIGURE 2



JOB SHEET #5

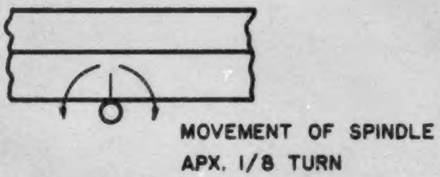
G. Pull the quill feed handle down until the point of the indicator is resting on the face of the solid jaw (Figure 3)

FIGURE 3


SOLID JAW
INDICATOR POINT

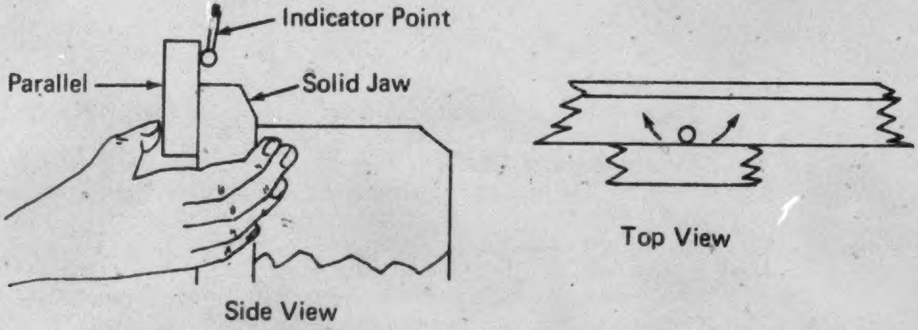
H. Rotate the indicator by turning spindle right and left to find maximum needle movement (Figure 4)

FIGURE 4


MOVEMENT OF SPINDLE
APX. 1/8 TURN

I. Raise the spindle and hold the parallel firmly against the back jaw with the thumb of one hand so it is against the point of the indicator, and rotate the spindle 180°. Rock the point of the indicator to find the center; note the reading (Figure 5)

FIGURE 5


Indicator Point
Parallel
Solid Jaw
Top View
Side View

J. Note the difference and move the table 1/2 the reading

(NOTE: Slack in the lead screw does not enter into the movement because you are moving with the indicator needle.)

K. Take another reading to make sure the indicator reads the same amount on the solid jaw and the parallel

DIAL INDICATORS
UNIT VI

JOB SHEET #6--USE DIAL INDICATOR TO CHECK HOLE LOCATIONS

I. Tools and equipment

A. Dial test indicator swivel point with height gage attachment

B. Height gage (12")

C. 4" angle plate

D. 2-3 C- clamps

E. Surface plate min. 12" x 18"

F. 6" calipers (vernier) or telescoping gage set and 0-1 micrometer

II. Materials

A. Pre-machined part 1/2" x 4" x 5" aluminum

B. Paper and pencil

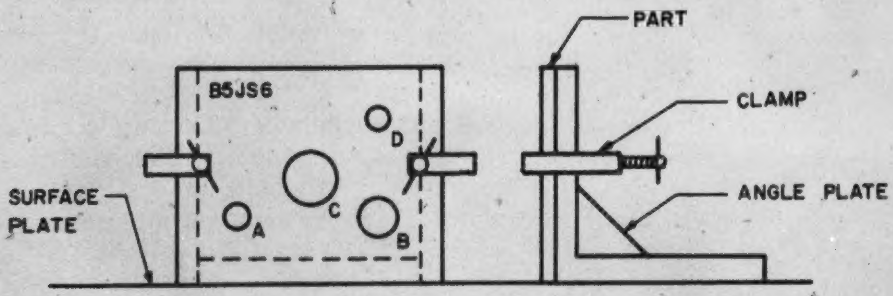
C. Print of part (See blueprint of part included in this job sheet)

III. Procedure

A. Clamp part to angle plate with 5" side down (Figure 1)

(NOTE: The 5" datum A is down on the surface plate.)

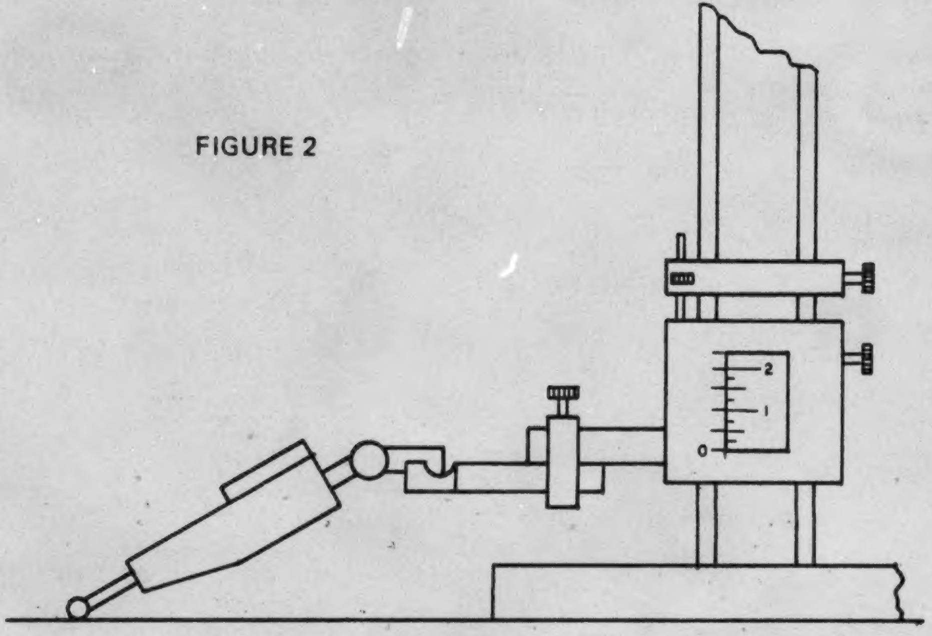
FIGURE 1



JOB SHEET #6

B. Mount indicator in holder of vernier height gage and zero indicator to vernier (Figure 2)

FIGURE 2



1. Set the vernier scale of the height gage to read zero inches and tighten clamping screws
2. Adjust the indicator down toward the table and adjust the point so it is almost parallel to the table
3. Apply light pressure to the indicator until the point touches the table and the needle moves approximately five thousandths
4. Rotate the face of the indicator until the needle and zero mark on the indicator are in line

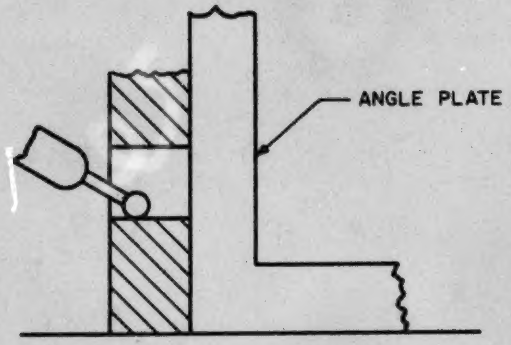
   (NOTE: With some indicators and verniers you cannot use zero on the vernier, so use a .500 or 1.000 gage block. As a result, you set the vernier on the thickness of the gage block and zero the indicator on the gage block.)

JOB SHEET #6

C. Loosen the clamping screws and slide the vernier slide up so the indicator point will go into the hole, and tighten lock screw of fine adjustment (Figure 3)

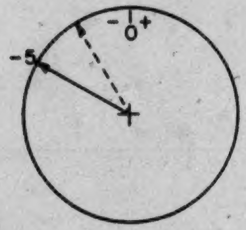
(CAUTION: Do not bump the indicator or move the face of the indicator or you will not have the two zeroed together. Adjust only with height gage.)

FIGURE 3



D. Move the height gage from side to side until the indicator is at the lowest reading (Figure 4)

FIGURE 4



When moving indicator, the lowest reading may be five. When moving indicator point right or left, five is where it stops dropping and starts moving back up.

E. With indicator at that point, use the fine adjustment screw and raise or lower vernier slide so the indicator needle is on zero

F. Check by moving indicator from side to side; the needle should never drop below zero

JOB SHEET #6

G. Remove indicator from hole and take reading from vernier height gage and record on a piece of paper

(NOTE: You will measure the diameter of the hole later and must add 1/2 the diameter to each reading to have location of center.)

H. Put datum line A down, clamp, and find and record readings for A, B, C, and D

I. Unclamp part and put datum B down and clamp as before

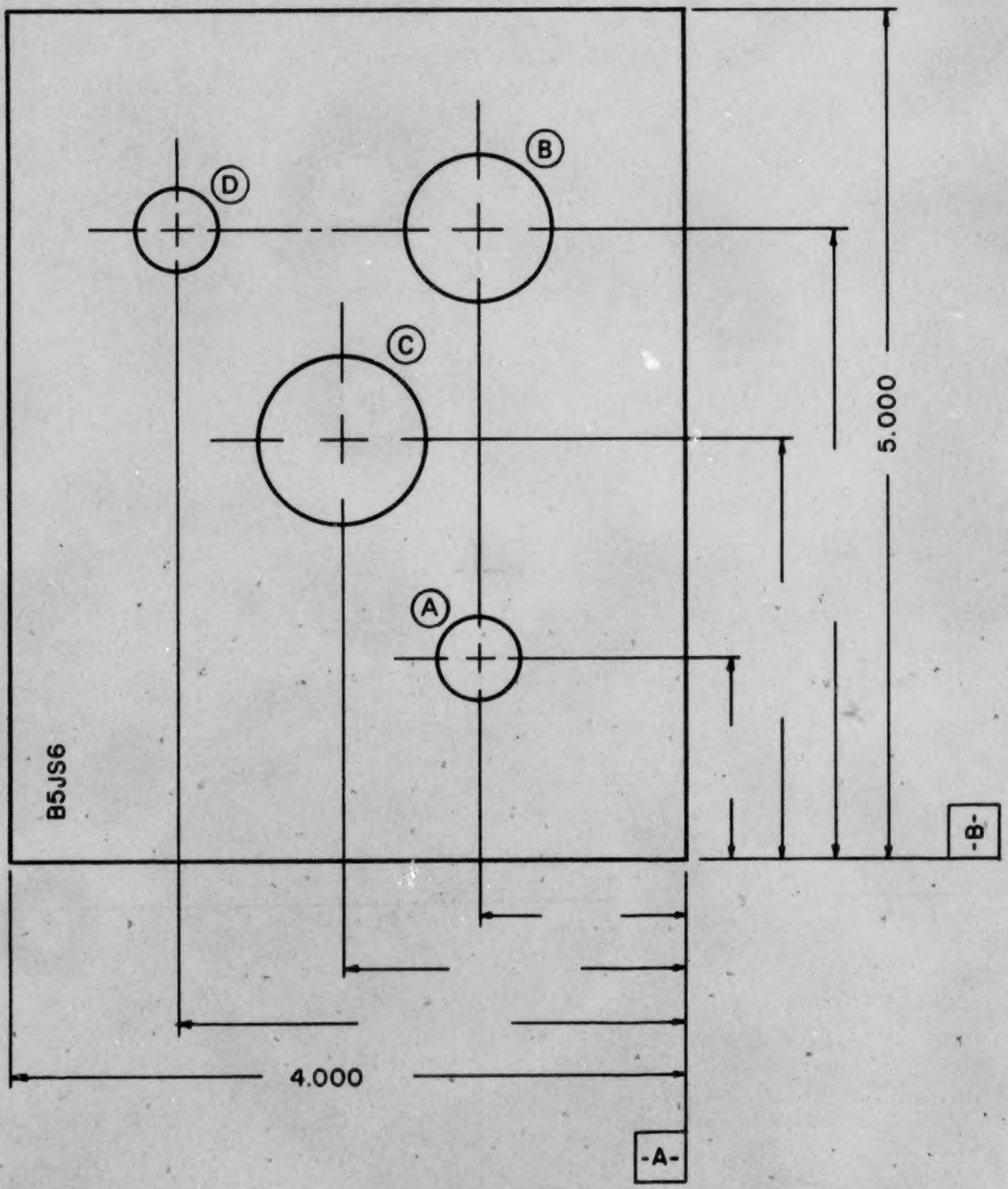
J. Find and record the readings for A, B, C, and D

K. Accurately measure holes A, B, C, and D

L. Divide each diameter by 2; then add that amount to the dimension obtained from vernier for that location, and write that dimension on your blueprint

M. Do this for all locations

JOB SHEET #6


D
B
C
A
B5JS6
5.000
-B-
4.000
-A-

DIAL INDICATORS
UNIT VI

JOB SHEET #7--USE DIAL INDICATOR TO CENTER ROTARY TABLE

I. Tools and equipment

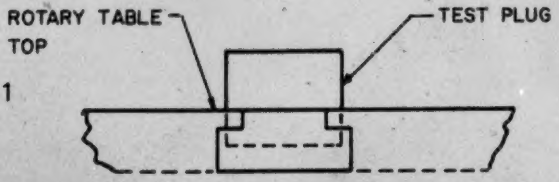
- A. Dial test indicator with attachments (swivel point)
- B. 12" or 10" rotary table
- C. T-bolts and nuts
- D. Wrenches
- E. Vertical or turret mill with drill chuck
- F. Test plug

II. Procedure

- A. If the head of the vertical mill has not been squared to the table, square it first
- B. Clean the table of the mill and the bottom of the rotary table since chips will cause rotary table to mount at an angle and cause dings in the table of the mill or rotary table

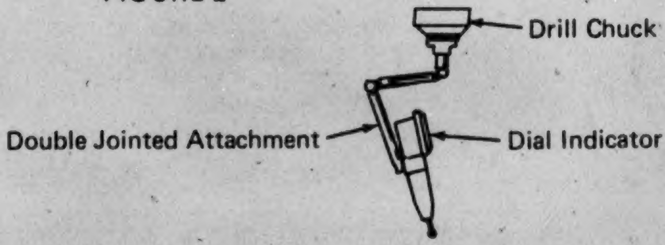
  (CAUTION: The rotary table is heavy and awkward to hold. Have someone help you lift it.)
- C. Set the rotary table on the mill table and secure in place with T-bolts and nuts
- D. Place the test plug in the center hole of the rotary table (Figure 1)

FIGURE 1



- E. Mount the indicator with double jointed swivel in the drill chuck (Figure 2)

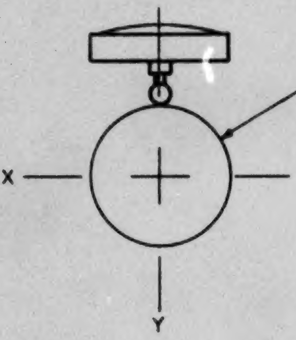
FIGURE 2



JOB SHEET #7

F. Make sure the movement of the indicator is parallel to the x or y axis movement of the mill table (Figure 3)

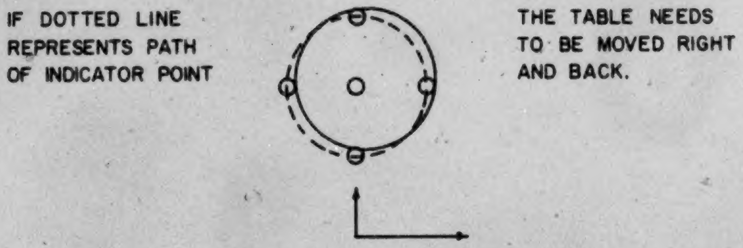
FIGURE 3



G. Put the vertical head in neutral position

H. With the indicator point just clearing the top of the test plug, move the point out to the edge of the work; rotate the chuck by hand to approximately align the spindle by moving the table in the x and y axis (Figure 4)

FIGURE 4



I. Bring the indicator down so it is in contact with the plug and rotate the spindle by hand. Note the indicator reading at 4 places approximately 90° to each other

J. Adjust the table by the longitudinal (x) and crossfeed (y) handles until the needle of the indicator registers no movement

(NOTE: X axis is referred to as longitudinal movement of the mill table; Y axis is referred to as crossfeed or transversal movement of the mill table.)

K. Lock the machine tables and recheck the alignment

L. Readjust if necessary

(NOTE: If you are mounting work on a rotary table, you first center the rotary table and then center the work. If using a hole, use a ground point; if aligning on a punch mark or cross mark, clamp the part to the rotary table.)

DIAL INDICATORS
UNIT VI

JOB SHEET #8--USE DIAL INDICATOR TO ALIGN TAILSTOCK OF LATHE

I. Tools and equipment

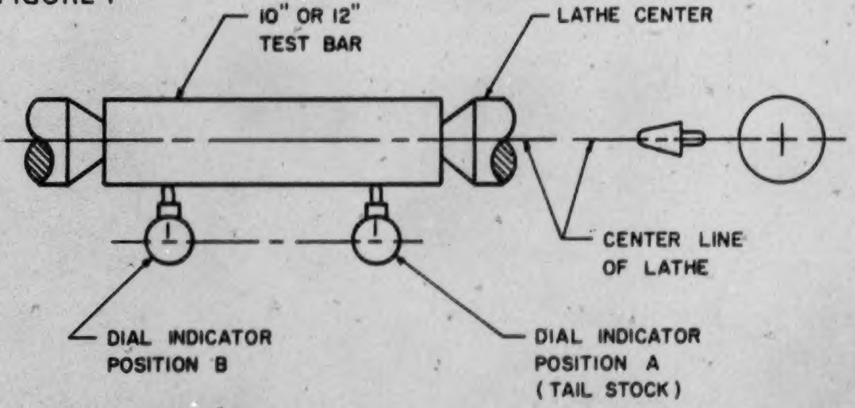
- A. Plunger dial indicator with clamp
- B. Magnetic base indicator holder
- C. Engine lathe with centers and adapter
- D. Test bar ground true

II. Procedure

- A. Clean the lathe and insert centers
- B. Mount the test bar between centers and adjust the tailstock spindle so bar is snug
- C. Lock the tailstock spindle
- D. Mount the indicator to the tool post with clamp or on the lathe carriage with the magnetic base (Figure 1)

  (NOTE: Make sure the indicator plunger is parallel to the lathe bed and that the point is center of line of lathe.)

FIGURE 1


10" OR 12" TEST BAR
LATHE CENTER
CENTER LINE OF LATHE
DIAL INDICATOR POSITION B
DIAL INDICATOR POSITION A (TAIL STOCK)

JOB SHEET #8

E. Adjust the cross-slide so the indicator registers approximately .020 at the tailstock end (See position A, Figure 1)

F. Move the carriage by hand to the headstock end (See position B, Figure 1) and note the indicator reading

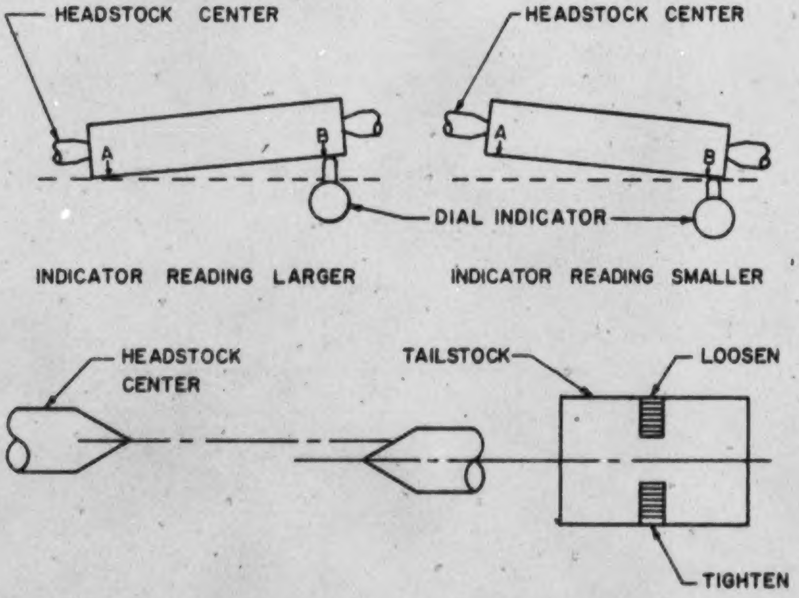
G. If the indicator readings are not the same, adjust the tailstock

(NOTE: Loosen tailstock clamp before moving.)

H. Move the carriage back to position A and loosen and tighten the two adjusting screws to shift the tailstock

I. Note how the reading changed when the indicator was moved from position A to B. If the reading got larger, the tailstock needs to be moved toward you; if it got smaller, move the tailstock away from you (Figure 2)

FIGURE 2


HEADSTOCK CENTER
A
B
HEADSTOCK CENTER
A
B
DIAL INDICATOR
INDICATOR READING LARGER
INDICATOR READING SMALLER
HEADSTOCK CENTER
TAILSTOCK
LOOSEN
TIGHTEN

J. When moving, leave the indicator in contact with test bar and shift the tailstock back to zero

K. Recheck by moving carriage from A to B; continue to adjust in the same manner until you have the same readings at A and B

DIAL INDICATORS
UNIT VI

TEST

NAME ______________________________ SCORE ______________

1. Match terms associated with dial indicators to the correct definitions. Write the correct numbers in the blanks provided.

_____a. Round surfaces which are true to each other

_____b. The total amount of movement of a dial indicator plunger

_____c. To make a part or attachment true

_____d. The difference an indicator reading will be at its maximum and minimum points

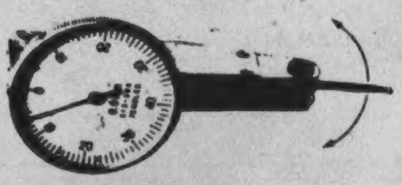
_____e. The amount of movement or misalignment of a part

_____f. Irregularities on a surface caused by abuse

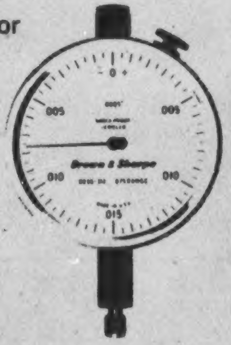
1. Align
2. Runout
3. Concentric
4. Dings
5. Range
6. Total indicator reading (TIR)

2. Identify the different types of indicators. Write the correct names in the blanks provided.

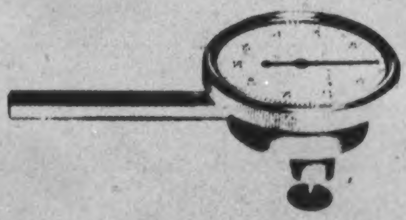
Vertical plunger dial indicator
Junior test indicator
Dial test indicator
Plunger back dial indicator



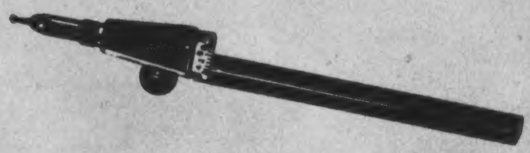
a. ______________________________



b. ______________________________



c. ______________________________



d. ______________________________

3. Select the proper type of indicator to do work required. Write the correct numbers in the blanks provided. Some tools may be used more than once, and more than one may be used to do the job described.

_____a. Used to align the head of a ram and turret mill perpendicular to table

_____b. Used in small places such as indicating on a hole or bore

_____c. Used when learning to use a dial indicator

_____d. Used with height gage for inspection

_____e. Used to align work true to spindle of lathe

_____f. Used to align a vise

_____g. Can be mounted to comparator, snap gages, thickness gages, or other fixtures for special applications

_____h. Used to align parts inside or outside when held in a lathe chuck

_____i. Used to align lathe tailstock, vertical head of mill, or work in lathe

1. Dial test indicator
2. Plunger back dial indicator
3. Vertical plunger dial indicator
4. Junior test indicator

4. State the rules for proper care of dial indicators.

a. Cleanliness-- ______________________________

____

____

b. Vibration-- ______________________________

____

____

c. Lubrication-- ______________________________

____

____

d. Handling-- ______________________________

____

____

e. Inspection-- ______________________________

____

____

f. While work is turning-- ______________________________

____

____

g. Revolving the indicator-- ______________________________

____

____

h. Exceeding the range-- ______________________________

____

____

5. Demonstrate the ability to:
   a. Align a vise.
   b. Align work in 4-jaw chuck with dial indicator.
   c. Align work clamped to angle plate parallel to surface plate.
   d. Align the head of a ram and turret mill.
   e. Referance the spindle to the solid jaw of a vise.
   f. Use dial indicator to check hole locations.
   g. Use dial indicator to center rotary table.
   h. Use dial indicator to align tailstock of lathe.

   (NOTE: If the above activities have not been finished before the test, ask your instructor when they should be completed.)

DIAL INDICATORS
UNIT VI

ANSWERS TO TEST

(NOTE: The point system designated in parentheses is intended to be a guideline and should be adapted as needed. The point total is 200.)

1. (6 points)
   a. 3
   b. 5
   c. 1
   d. 6
   e. 2
   f. 4

2. (8 points)
   a. Dial test indicator
   b. Vertical plunger dial indicator
   c. Plunger back dial indicator
   d. Junior test indicator

3. (10 points)
   a. 2 or 3
   b. 1
   c. 4
   d. 1
   e. 2
   f. 2 or 4
   g. 3
   h. 4
   i. 3

4. (16 points)
   a. Keep the indicator stored in a box free of dirt and grease; otherwise the spindle has a tendency to stick, giving you a bad reading
   b. Do not hammer on objects with indicator point in contact with work or you can damage the indicator
   c. Never lubricate dial indicators; this causes them to become sluggish
   d. Always handle with care and check secureness of setup so the indicator will not fall
   e. Inspect the indicator by mounting it on a comparator stand and using a gage block to see if spindle moves the correct amount
   f. It is not a good practice to use machine power to turn work while point is in contact with work; it causes a flat on the point of the indicator

GAGING AND INSPECTION TOOLS
UNIT VII

UNIT OBJECTIVE

After completion of this unit, the student should be able to use precision gages and inspection tools. This knowledge will be shown by completion of assignment sheets, job sheets, and unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with gaging and inspection tools to the correct definitions.
2. Identify different gages.
3. Identify different inspection tools.
4. Describe rules for care of gaging and inspection tools.
5. Match gaging tools to their correct uses.
6. Match inspection tools to their correct uses.
7. Select the minimum gage blocks required for a particular setting.
8. Use trigonometric function tables to calculate sine bar elevation.
9. Demonstrate the ability to:
    a. Use gage blocks.
    b. Use sine bar to set angle.

GAGING AND INSPECTION TOOLS
UNIT VII

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

   A. Provide students with objective sheet.

   B. Provide students with information and assignment sheets.

   C. Discuss unit and specific objectives.

   D. Discuss information and assignment sheets.

   E. Demonstrate the mechanics of solving problems on a chalkboard.

   F. Tell students what these tools are used for and why it is important that they learn to use them correctly.

   G. Demonstrate and discuss procedures outlined in job sheets

   H. If possible, have a quality control person come in and talk with students.

   I. NOTE: Trigonometric function tables are necessary to complete Assignment Sheet #2 and test question #8. Obtain copies for students.

   J. Give test.

   K. Reteach and retest if necessary.

II. Instructional materials:

   A. Objective sheet

   B. Information sheet

   C. Assignment sheets

      1. Assignment Sheet #1--Calculate Gage Blocks

      2. Assignment Sheet #2--Use Trigonometric Function Tables to Calculate Sine Bar Elevation

   D. Job sheets

      1. Job Sheet #1--Use Gage Blocks

      2. Job Sheet #2--Use Sine Bar to Set Angle

   E. Test

   F. Answers to test

III. Unit references:

A. *The Shop Tool Manual.* Brown & Sharpe Catalog #STM76. North Kingston, RI: Brown & Sharpe Manufacturing Company.

B. Krar, S.F.; Oswald, J.W.; and St. Amand, J.E. *Technology of Machine Tools.* Toronto: McGraw-Hill Book Company of Canada, 1969.

C. *Starrett Catalog #28.* Athol, MA: The L.S. Starrett Company, 1979.

GAGING AND INSPECTION TOOLS
UNIT VII

INFORMATION SHEET

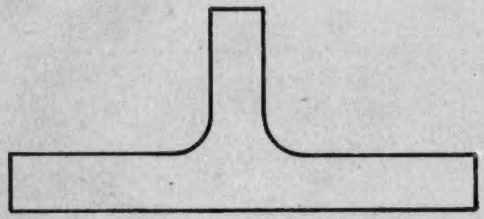
I. Terms and definitions

A. Standard--A set unit of measurement for checking precision measuring tools

B. Transfer--To convey a measurement from one place to another

C. Fillet--Concave junction formed where two surfaces meet

Example:



D. Pitch--Distance from any point on the thread of a screw to a corresponding point on an adjacent thread, measured parallel to the axis

E. Pitch diameter--The diameter of an imaginary cylinder which passes through the threads at a point where the groove and thread widths are equal

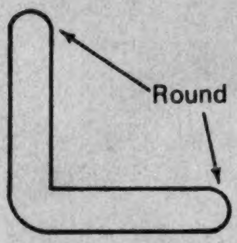
F. "Go" and "no-go"--Refers to the upper and lower limits of a part when used in conjunction with a gage

G. Parallelism--All parts on the controlled surface must lie within the tolerance zone, which is parallel to a particular surface

H. Concentricity--All diameters have a common center

I. Round--A convex surface on the edge of a part

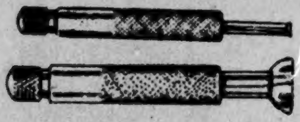
Example:



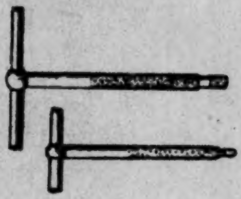
INFORMATION SHEET

II. Gages

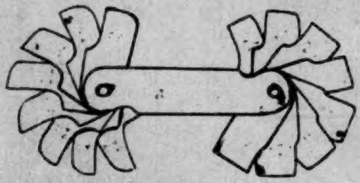
A. Small hole gages



B. Telescoping gages

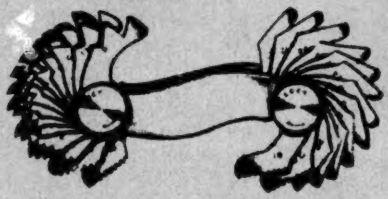


C. Radius gages



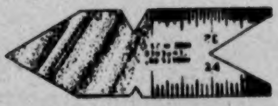
Used with permission of the L. S. Starrett Company

D. Screw pitch gages



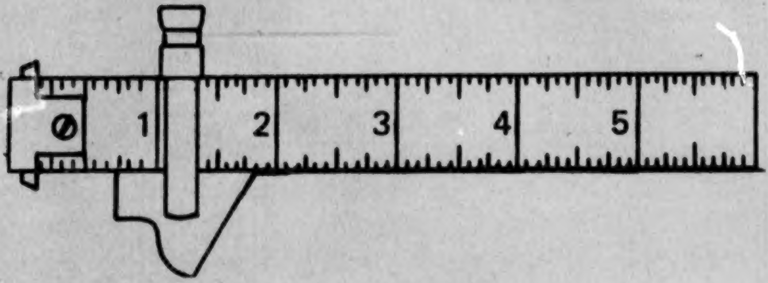
INFORMATION SHEET

E. Center gage



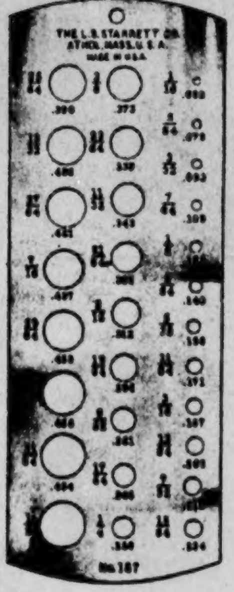
Used with permission of the L. S. Starrett Company

F. Drill point gage

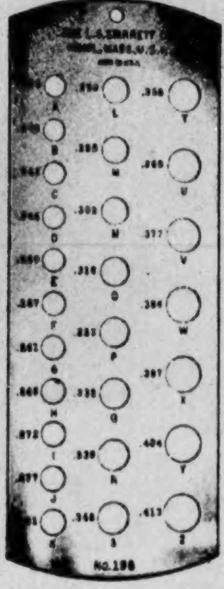


INFORMATION SHEET

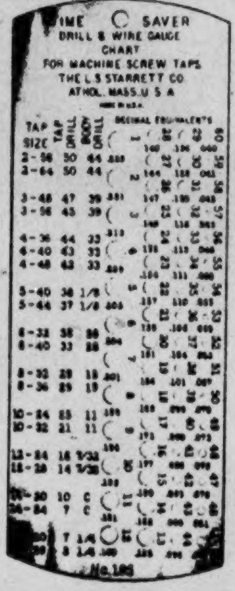
G. Drill and wire gages


THE L.S. STARRETT CO.
ATHOL, MASS. U.S.A.
MADE IN U.S.A.
No. 187

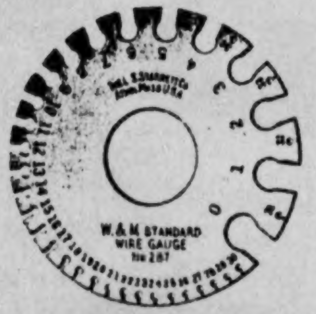
Fractional Drill Gage


THE L.S. STARRETT CO.
No. 188

Letter Drill Gage


TIME SAVER
DRILL & WIRE GAUGE
CHART
FOR MACHINE SCREW TAPS
THE L.S. STARRETT CO.
ATHOL, MASS. U.S.A.
TAP SIZE
TAP DRILL
BODY DRILL
DECIMAL EQUIVALENTS
No. 185

Number Drill Gage

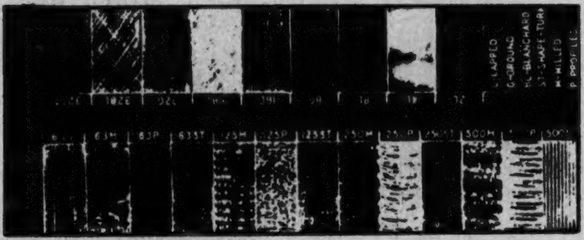

THE L.S. STARRETT CO.
ATHOL, MASS. U.S.A.
W. & M. STANDARD
WIRE GAUGE
No. 287

Steel Wire Gage

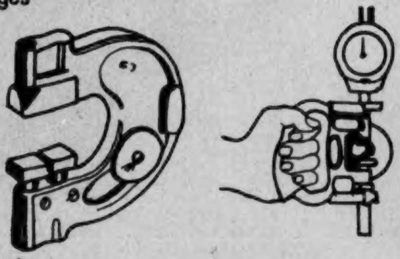
Used with permission of the L. S. Starrett Company

INFORMATION SHEET

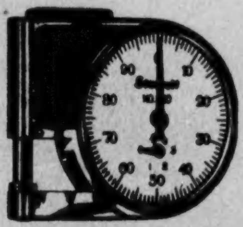
H. Surface finish gage


L-LAPPED
G-GROUND
HL-BLANCHARD
ST-SHAPE-TURN
M-MILLED
P-PROFILED
63H
63P
63ST
125H
125P
125ST
250H
250ST
500H

I. Snap gages



J. Dial thickness gage


90
10
80
20
70
30
60
40
50

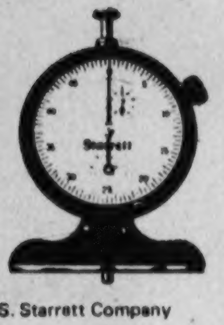
Used with permission of the L. S. Starrett Company

K. Dial bore gage

Used with permission of the L. S. Starrett Company

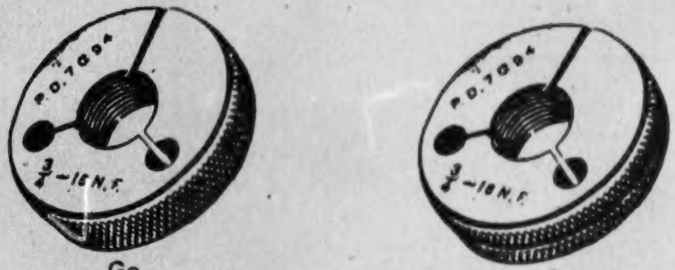
INFORMATION SHEET

L. **Dial depth gage**



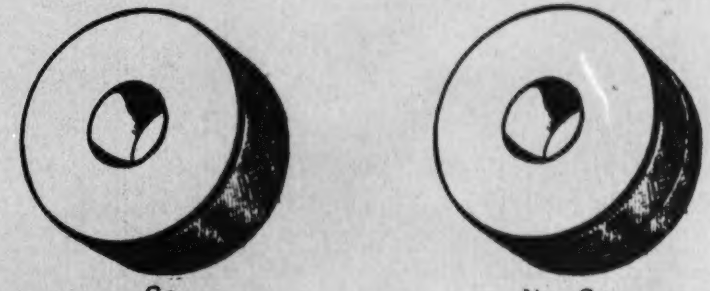
Used with permission of the L. S. Starrett Company

M. **Thread ring gages**


P.D.7G94
3/4-16 N.F.
P.D.7G94
3/4-16 N.F.

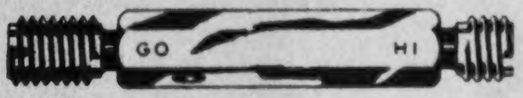
Go No - Go

N. **Ring gages**



Go No - Go

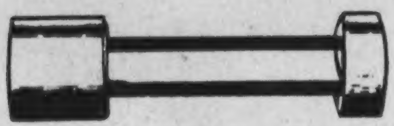
O. **Thread plug gage**



Go No-Go

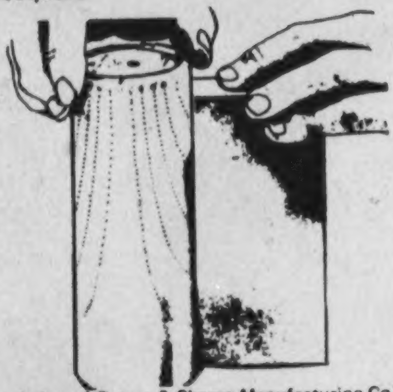
INFORMATION SHEET

P. Cylindrical plug gage



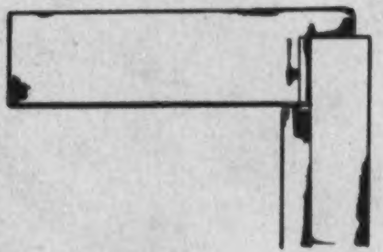
III. Inspection tools

A. Cylindrical square



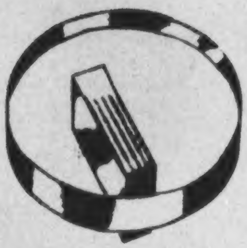
Used with permission of Brown & Sharpe Manufacturing Co.

B. Bevel edge steel square

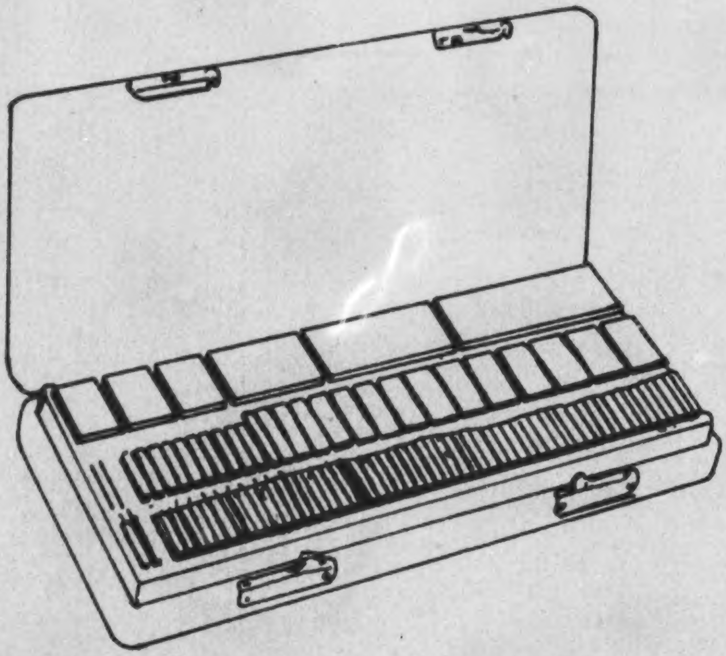


INFORMATION SHEET

C. Optical flat



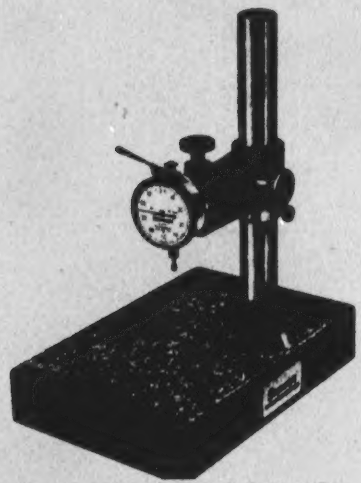
D. Gage blocks (Johannson or Jo blocks)



INFORMATION SHEET

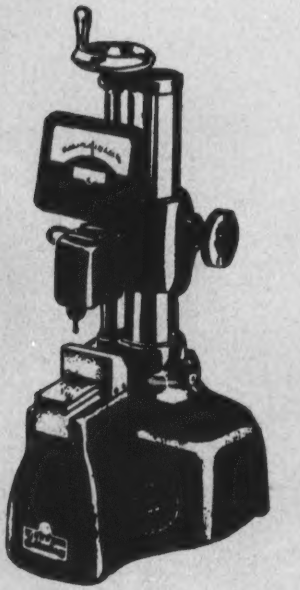
E. Comparators

1. Comparator (Transfer stand with indicator)



Used with permission of the L. S. Starrett Company

2. Electronic comparator



INFORMATION SHEET

3. Optical comparator

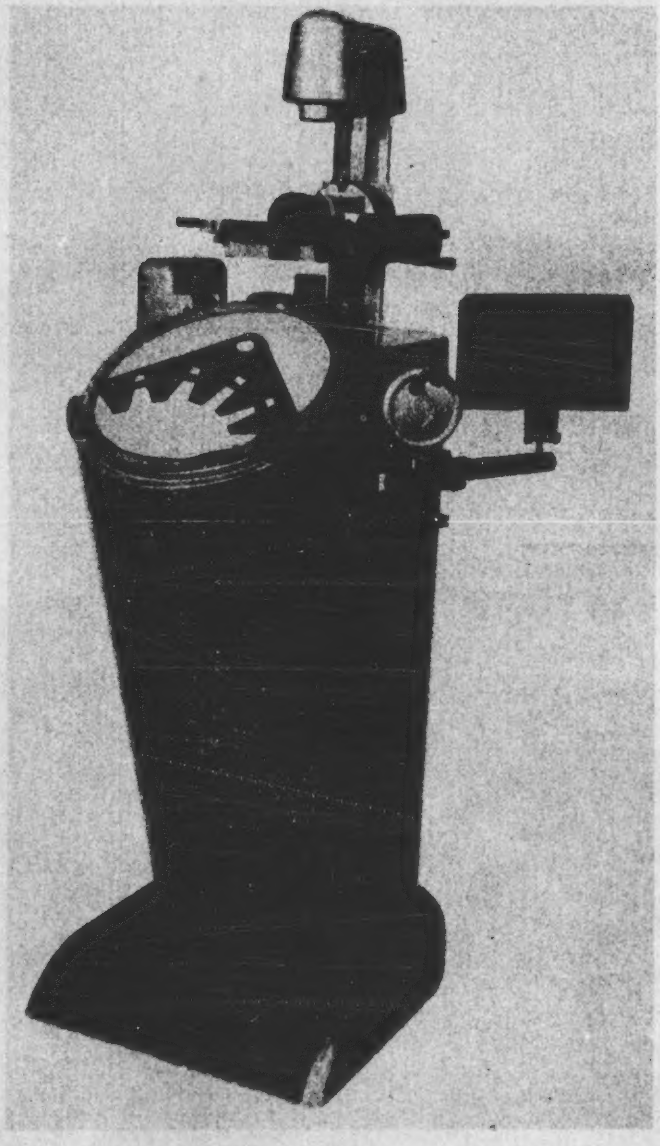
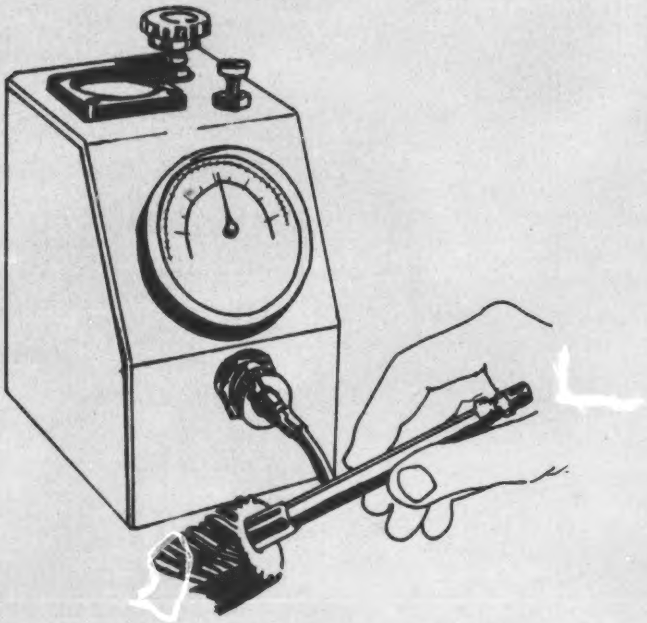


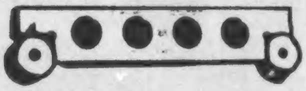
Photo courtesy of RANK SCHERR-TUMICO, INC.

INFORMATION SHEET

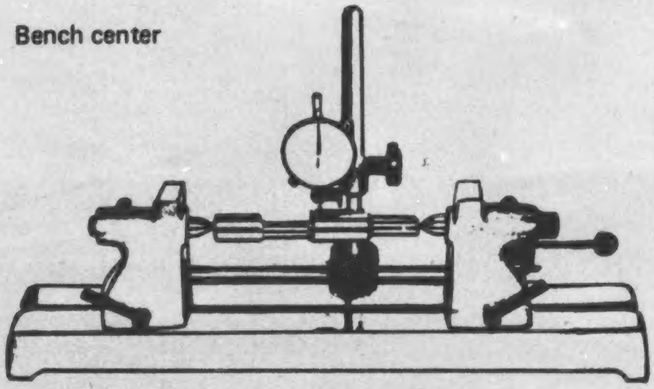
F. Pressure type air gage



G. Sine bar

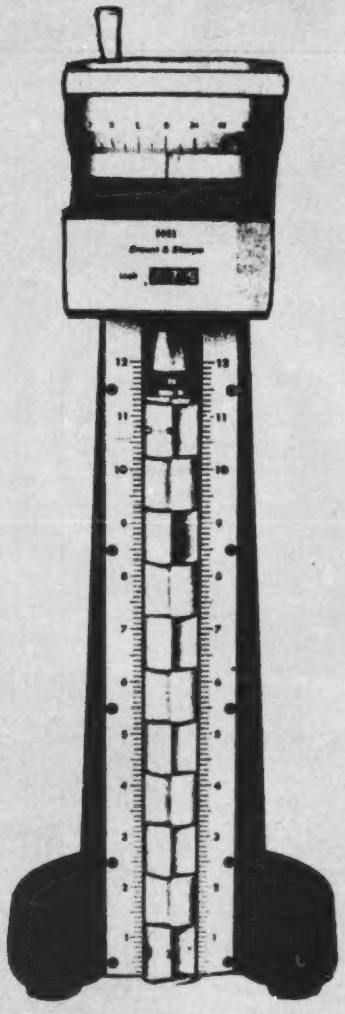


H. Bench center



INFORMATION SHEET

I. **Height micrometer**


Brown & Sharpe
12
11
10
9
8
7
6
5
4
3
2
1

Used with permission of Brown & Sharpe Manufacturing Co.

INFORMATION SHEET

IV. Rules for care of gaging and inspection tools

- A. Handling--Always handle precision tools with care; never throw them around or lay parts on them
- B. Cleaning--Wipe tools with a clean rag after using
- C. Storage--When you are finished using tools put them up, back in box, or cover with dust cover
- D. Lubricating--Never lubricate plungers of indicators; however, other metal parts should be lubricated with a thin coat of oil to prevent rust

  (NOTE: If you are not sure whether tools should be lubricated, ask your instructor.)
- E. Inspecting--Before using most gages and inspection tools, check them against a standard to be sure of their accuracy

V. Uses of gaging tools

- A. Small hole gage--Used to measure small holes, slots, and grooves by transferring measurements to outside micrometer; range is 1/8" to 1/2"
- B. Telescoping gage--Used to measure holes, slots, and recesses by transferring measurements to outside micrometer; range is 5/16" to 6"
- C. Radius gage--Used to check a radius or fillet
- D. Screw pitch gage--Used to determine the pitch or number of threads per inch of a threaded part
- E. Center gage--Used to check 60° threading tool when grinding to shape, to set threading tool when cutting threads, and to check centers
- F. Drill point gage--Used when drill grinding to determine the correct drill point angle
- G. Drill and steel wire gage--Used to check size of drills and steel wire

  (NOTE: These gages are in fractional, number, letter, and wire gage sizes.)
- H. Snap gages--Used to check parts within certain limits of a predetermined, fixed dimension

  (NOTE: Snap gages may or may not have a dial indicator mounted to show the amount of variation, and may be mounted or hand-held.)

INFORMATION SHEET

I. Dial thickness gage--Used as a fast method of checking the thickness of sheet material

J. Dial bore gage--Used to check the bore of parts to .0001 accuracy; must be preset with a ring gage

K. Dial depth gage--Used to check the depth of holes, slots, grooves, and recesses

L. Thread ring gage--Used to check the pitch diameter of a threaded part

(NOTE: Threading gages are usually used in pairs as "go" and "no-go.")

M. Ring gage--Used to set, check tools, and measure parts to .0001 accuracy

N. Thread plug gage--Has "go" and "no-go" threaded ends; used to check pitch diameter of internal threads

O. Cylindrical plug gage--Has "go" and "no-go" ends; used to check bore of parts to .0001 accuracy

P. Surface finish gage--Used to visually compare the desired finish of a part to a certain known finish

VI. Uses of inspection tools

A. Cylindrical square--Used as a master square against which other squares may be checked

B. Bevel edge steel square--Used to inspect parts for squareness

C. Optical flat--Uses light waves to measure flatness, parallelism, and size

D. Gage blocks--Used to check measurements, set fixed gages, calibrate measuring tools, set comparators, inspect, and perform other set-ups

(NOTE: Gage blocks are manufactured to size within one-millionths accuracy.)

E. Sine bar--Used to set up or inspect angular surfaces of 45° or less

F. Bench center--Used to check concentricity of machined parts

G. Comparator--Used to inspect size of parts from a flat surface

H. Height micrometer--Used to set other measuring tools for inspection by comparison; accurate to .0001 of an inch

I. Electronic comparator--Used in inspection of parts; is preset and measures in the millionths of an inch (.000001)

INFORMATION SHEET

J. Pressure type air gage--Used for inspection of parts to a very close tolerance with air flow

K. Optical comparator--Used as a visual method of inspection

VII. Gage block selection (Assignment Sheet #1)

A. Look over the sizes of gage blocks found in the gage block set; note the sizes and differences in each series

Example:

FIRST: .0001 Series -- 9 Blocks

.1001 .1002 .1003 .1004 .1005 .1006 .1007 .1008 .1009

SECOND: .001 Series -- 49 Blocks

.101 .102 .103 .104 .105 .106 .107 .108 .109
.110 .111 .112 .113 .114 .115 .116 .117 .118
.119 .120 .121 .122 .123 .124 .125 .126 .127
.128 .129 .130 .131 .132 .133 .134 .135 .136
.137 .138 .139 .140 .141 .142 .143 .144 .145
.146 .147 .148 .149

THIRD: .050 Series -- 19 Blocks

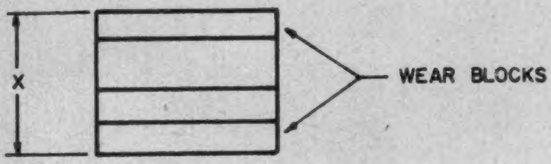
.050 .100 .150 .200 .250 .300 .350 .400 .450 .500
.550 .600 .650 .700 .750 .800 .850 .900 .950

FOURTH: 1.000 Series -- 4 Blocks

1.000 2.000 3.000 4.000

TWO .050 WEAR BLOCKS

(NOTE: A set may have two .050 wear blocks, used as the first and last blocks when making up dimensions.)



INFORMATION SHEET

B. Try to obtain the required dimension with as few blocks as possible

1. Write the dimension down
2. Subtract a gage block that will reduce the right-hand digit to zero until you have dimension or a whole inch remaining

   (NOTE: Each gage block size can be used only once when making up a dimension.)

   Examples:

Required distance			Checking
0.9844	.8840	.7500	.750
- .1004	- .1340	- .7500	.134
			.1004
.8840	.7500	0	.9844

Required distance	Checking
2.4531	2.000
- .1001	.250
2.3530	.103
- .103	.1001
2.250	2.4531 = required distance
- .250	
2.000	
-2.000	
0	

(NOTE: Examples did not use wear blocks.)

INFORMATION SHEET

VIII. Use of trigonometric function tables to calculate sine bar elevation (Assignment Sheet #2)

A. Find the sine of desired angle by using a natural trigonometric function table

Example:

Sine of 24°15' = .41072

24° Natural Trigonometric Functions

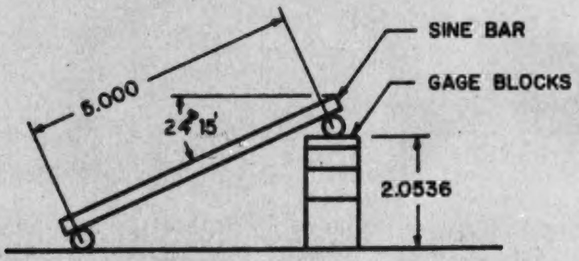
M	Sine	Cosine	Tan.	Coten.	Secant	Cosec.	M
0	0.40674	0.91354	0.44523	2.2460	1.0946	2.4586	60
1	.40700	.91343	.44558	.2443	.0948	.4570	59
2	.40727	.91331	.44593	.2425	.0949	.4554	58
3	.40753	.91319	.44627	.2408	.0951	.4538	57
4	.40780	.91307	.44662	.2390	.0952	.4522	56
5	0.40806	0.91295	0.44697	2.2373	1.0953	2.4506	55
6	.40833	.91283	.44732	.2355	.0955	.4490	54
7	.40860	.91271	.44767	.2338	.0956	.4474	53
8	.40886	.91260	.44802	.2320	.0958	.4458	52
9	.40913	.91248	.44837	.2303	.0959	.4442	51
10	0.40939	0.91236	0.44872	2.2286	1.0961	2.4426	50
11	.40966	.91224	.44907	.2268	.0962	.4411	49
12	.40992	.91212	.44942	.2251	.0963	.4395	48
13	.41019	.91200	.44977	.2234	.0965	.4379	47
14	.41045	.91188	.45012	.2216	.0966	.4363	46
15	0.41072	0.91176	0.45047	2.2199	1.0968	2.4347	45
16	.41098	.91164	.45082	.2182	.0969	.4332	44
17	.41125	.91152	.45117	.2165	.0971	.4316	43
18	.41151	.91140	.45152	.2147	.0972	.4300	42
19	.41178	.91128	.45187	.2130	.0973	.4285	41
20	0.41204	0.91116	0.45222	2.2113	1.0975	2.4269	40

(NOTE: In the sine column 24°0' = .40674, and by dropping down the M column to 15 you have 24°15' = .41072.)

B. Multiply the sine of the angle by the length of the bar

Example: 5" sine bar to be set at 24°15'

.41072 = Sine of the angle
5 = Length of bar
2.05360 = Elevation of sine bar



GAGING AND INSPECTION TOOLS
UNIT VII

ASSIGNMENT SHEET #1--CALCULATE GAGE BLOCKS

NAME ______________________________ SCORE ______________

Calculation is something a good machinist is expected to do quickly and accurately.

Working from the 83 piece gage block set below, list the size of blocks required to obtain the dimensions listed. Remember that each block can be used once per set-up.

(NOTE: Use the least number of gage blocks possible.)

FIRST: .0001 Series -- 9 Blocks

.1001 .1002 .1003 .1004 .1005 .1006 .1007 .1008 .1009

SECOND: .001 Series -- 49 Blocks

.101 .102 .103 .104 .105 .106 .107 .108 .109
.110 .111 .112 .113 .114 .115 .116 .117 .118
.119 .120 .121 .122 .123 .124 .125 .126 .127
.128 .129 .130 .131 .132 .133 .134 .135 .136
.137 .138 .139 .140 .141 .142 .143 .144 .145
.146 .147 .148 .149

THIRD: .050 Series – 19 Blocks

.050 .100 .150 .200 .250 .300 .350 .400 .450 .500
.550 .600 .650 .700 .750 .800 .850 .900 .950

FOURTH: 1.000 Series – 4 Blocks

1.000 2.000 3.000 4.000

TWO .050 WEAR BLOCKS

1. .8906

2. 3.3937

ASSIGNMENT SHEET #1

3. 4.9111

4. 1.1256

GAGING AND INSPECTION TOOLS
UNIT VII

ASSIGNMENT SHEET #2–USE TRIGONOMETRIC FUNCTION TABLES TO CALCULATE SINE BAR ELEVATION

NAME ______________________________ SCORE ______________

Use trigonometric function tables supplied by your instructor to complete this assignment sheet. Perform the necessary calculations to determine the elevation of a 5" sine bar if it is to be set at the following angles.

1. 10°15' = __________

2. 21°38' = __________

3. 30°10' = __________

4. 15°45' = __________

5. 36°5' = __________

GAGING AND INSPECTION TOOLS
UNIT VII

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

1. .1006
   .140
   .650
   .8906

2. .1007
   .143
   .150
   3.000
   3.3937

3. .1001
   .111
   .700
   4.000
   4.9111

4. .1006
   .125
   .900
   1.1256

Assignment Sheet #2

1. .8897
2. 1.8433
3. 2.5126
4. 1.3572
5. 2.9448

GAGING AND INSPECTION TOOLS
UNIT VII

JOB SHEET #1--USE GAGE BLOCKS

I. Tools and equipment

A. 83-piece gage block set

B. Gage block cleaner

C. Gage block preservative

D. Clean, soft, lintless cloths or thin paper

II. Procedure

A. Determine the gage blocks you need to obtain the distance required, using as few blocks as possible

Example: Step 1: Write the dimension down on paper
1.8756

Step 2: Subtract a block that will eliminate the right-hand digit

```
 1.8756
  .1006
 ------
 1.7750
```

Step 3: Use blocks which will eliminate the number from the digits and replace them with zero or a five

```
 1.7750
-  .1250
 ------
 1.6500
-  .6500
 ------
 1.0000
- 1.0000
 ------
 0.0000
```

Therefore, to obtain the dimension 1.8756 you used 4 gage blocks.

```
  1.000
   .6500
   .1250
 + .1006
 -------
  1.8756
```

JOB SHEET #1

B. Using the 83-piece gage block set, write down the gage blocks required to obtain the dimensions given

1. 3.5873

2. .8716

FIRST: .0001 Series – 9 Blocks

.1001 .1002 .1003 .1004 .1005 .1006 .1007 .1008 .1009

SECOND: .001 Series – 49 Blocks

.101 .102 .103 .104 .105 .106 .107 .108 .109
.110 .111 .112 .113 .114 .115 .116 .117 .118
.119 .120 .121 .122 .123 .124 .125 .126 .127
.128 .129 .130 .131 .132 .133 .134 .135 .136
.137 .138 .139 .140 .141 .142 .143 .144 .145
.146 .147 .148 .149

THIRD: .050 Series – 19 Blocks

.050 .100 .150 .200 .250 .300 .350 .400 .450 .500
.550 .600 .650 .700 .750 .800 .850 .900 .950

FOURTH: 1.000 Series – 4 Blocks

1.000 2.000 3.000 4.000

TWO .050 WEAR BLOCKS

C. Set the required gage blocks on a clean, lint-free cloth

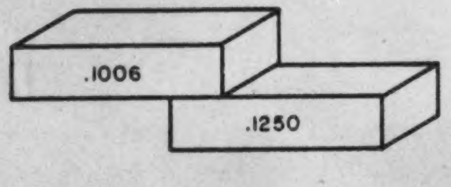
D. Use gage block cleaner and soft rag and remove the preservative

E. Wipe each of the contacting surfaces with lintless cloth or thin paper

F. Place the end of one block over the end of another block as shown (Figure 1)

(NOTE: It is best to begin with the smallest block and add each larger size.)

FIGURE 1



G. Apply pressure on the two blocks and slide one over the other

(NOTE: If the blocks do not adhere to each other, it is usually because the blocks are not clean. Re-clean and repeat step F.)

JOB SHEET #1

H. Slide the third block onto the other two blocks

I. Slide on the fourth block

(NOTE: When put together properly, gage blocks can stand a 200-pound pull without separating.)

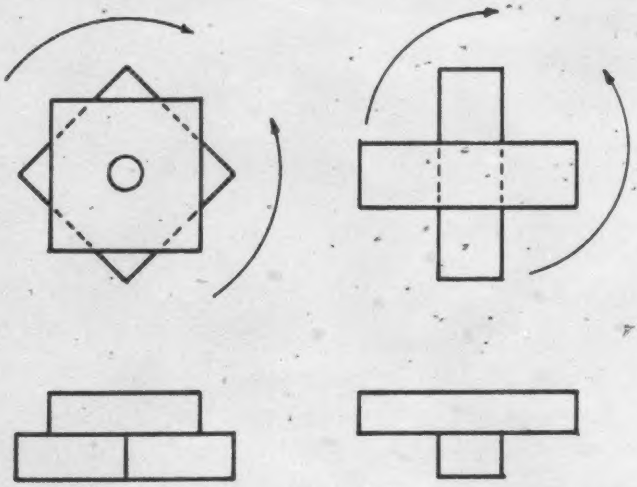
(CAUTION: Always work over a bench with a cloth covering the top, and avoid scratching the shiny surfaces of the gage blocks.)

J. Make up 2.7508 and 1.3127 for additional practice

K. Separate gage blocks by sliding them off in the same manner they were put together

(NOTE: The method shown above is not for wringing blocks; wringing is the turning of one block clockwise and the other counterclockwise. See Figure 2 for example.)

FIGURE 2



SQUARE TYPE

RECTANGULAR TYPE

GAGING AND INSPECTION TOOLS
UNIT VII

JOB SHEET #2--USE SINE BAR TO SET ANGLE

I. Tools and equipment

- A. Gage block set
- B. Gage block cleaner
- C. Gage block preservative
- D. Clean soft cloths
- E. 5" sine bar
- F. 30° ground angle
- G. Surface gage with dial test indicator
- H. Surface plate
- I. Surface plate cleaner
- J. Angle plate

(NOTE: A height gage may be substituted for the surface gage.)

II. Procedure

A. Calculate for elevation of sine bar

Example: $E = 5 \times \text{sine of } 30^\circ$

$$\begin{array}{r} \text{Sine of } 30^\circ 0' = .5000 \\ \times \quad 5 \\ \hline 2.5000 \end{array} = \text{Elevation}$$

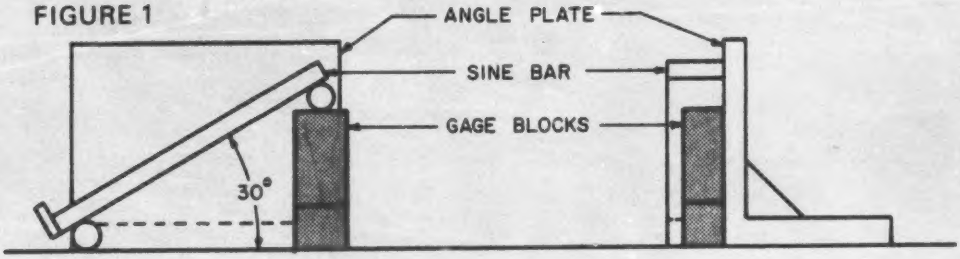
B. Clean gage blocks 2.000 and .500 with soft cloth and gage block cleaner

C. Slide the gage blocks together

D. Clean surface plate with surface plate cleaner

E. Set gage blocks under end of sine bar and back with angle plate (Figure 1)

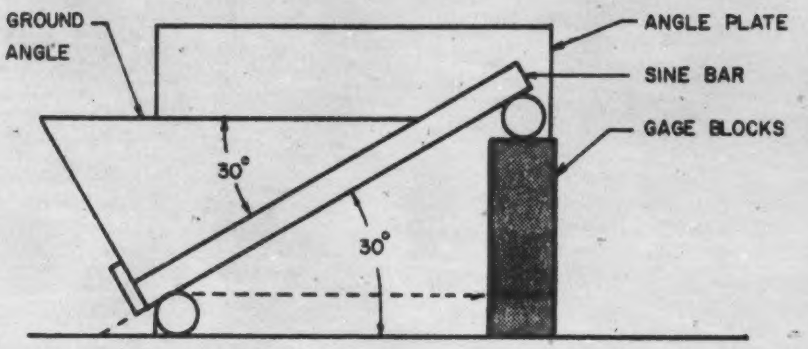
FIGURE 1



JOB SHEET #2

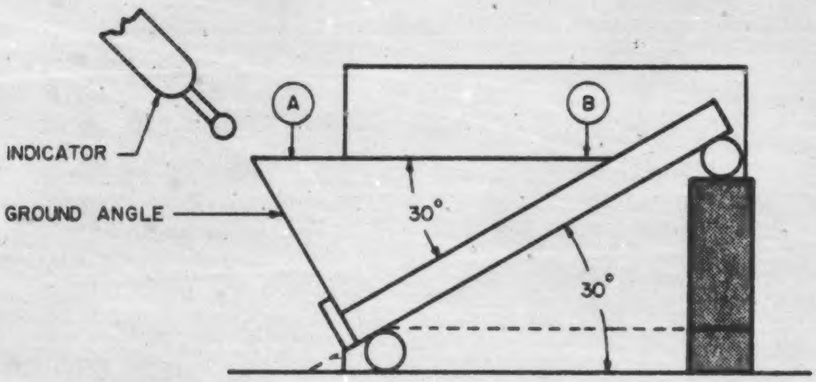
F. Set 30° ground angle on sine bar as shown (Figure 2)

FIGURE 2


GROUND ANGLE
ANGLE PLATE
SINE BAR
GAGE BLOCKS
30°
30°

G. Check with test indicator; if the part is ground correctly, the indicator should read "0" (zero) at points A and B (See Figure 3)

FIGURE 3


A
B
INDICATOR
GROUND ANGLE
30°
30°

GAGING AND INSPECTION TOOLS
UNIT VII

TEST

NAME ______________________________ SCORE ______________

1. Match terms associated with gaging and inspection tools to the correct definitions. Write the correct numbers in the blanks provided.

_____a. Refers to the upper and lower limits of a part when used in conjunction with a gage

_____b. All diameters have a common center

_____c. A set unit of measurement for checking precision measuring tools

_____d. All parts on the controlled surface must lie within the tolerance zone, which is parallel to a particular surface

_____e. The diameter of an imaginary cylinder which passes through the threads at a point where the groove and thread widths are equal

_____f. To convey a measurement from one place to another

_____g. A convex surface on the edge of a part

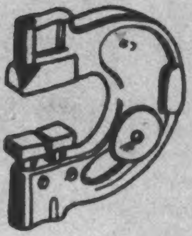
_____h. Distance from any point on the thread of a screw to a corresponding part on an adjacent thread, measured parallel to the axis

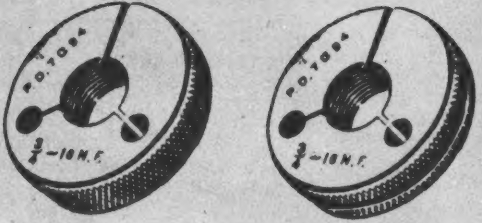
_____i. Concave junction formed where two surfaces meet

1. Standard
2. Transfer
3. Fillet
4. Pitch
5. Pitch diameter
6. "Go" and "no-go"
7. Parallelism
8. Concentricity
9. Round

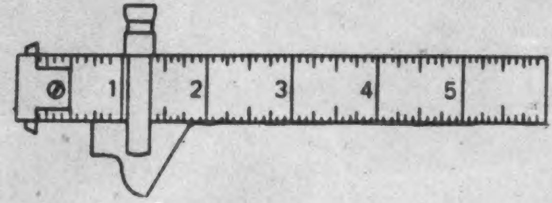
2. Identify the different gages illustrated on the next pages by writing the correct names in the blanks provided.

Center gage
Screw pitch gages
Radius gages
Telescoping gages
Small hole gages
Dial thickness gage
Snap gage
Ring gages
Fractional drill gage
Steel wire gage
Dial bore gage
Dial depth gage
Thread ring gages
Cylindrical plug gage
Thread plug gage
Drill point gage
Surface finish gage
Letter drill gage
Number drill gage

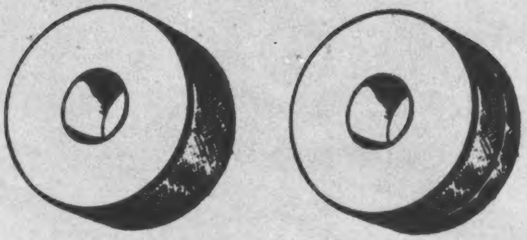


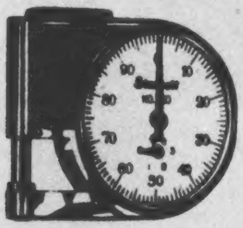

P.D. 7094
$\frac{3}{4}$ – 10 N.F.
P.D. 7094
$\frac{3}{4}$ – 10 N.F.

a. ____________________ b. ____________________

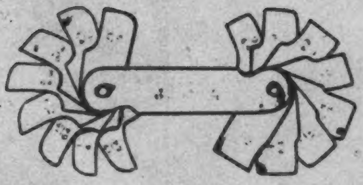


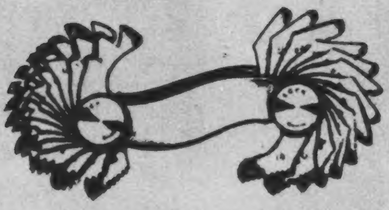
c. ____________________



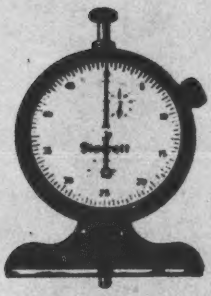


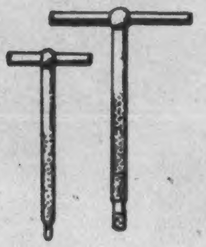
d. ____________________ e. ____________________

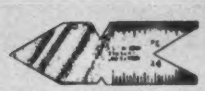




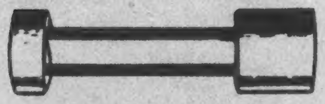
f. ____________________ g. ____________________

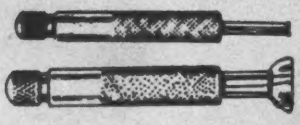




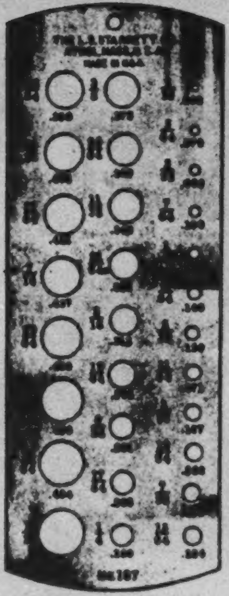


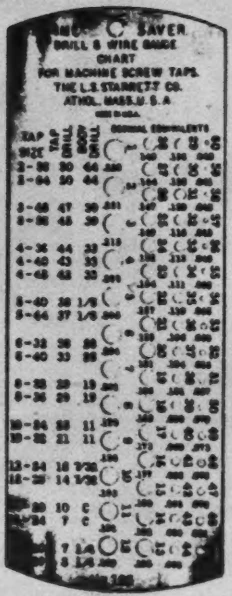
h. ____________ i. ____________ j. ____________



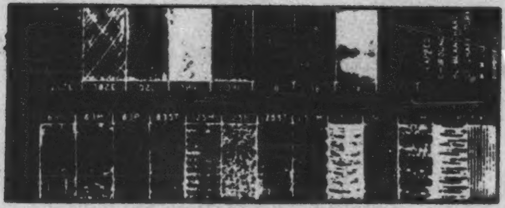


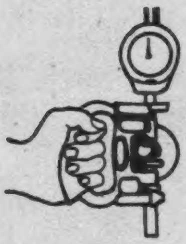
k. ____________________ l. ____________________


THE L.S. STARRETT CO.
ATHOL, MASS. U.S.A.
MADE IN U.S.A.

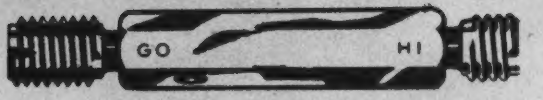

MONEY SAVER
DRILL & WIRE GAGE
CHART
FOR MACHINE SCREW TAPS.
THE L.S. STARRETT CO.
ATHOL, MASS. U.S.A.
TAP SIZE
TAP DRILL
BODY DRILL
DECIMAL EQUIVALENTS

m. ______________________________ n. ______________________________

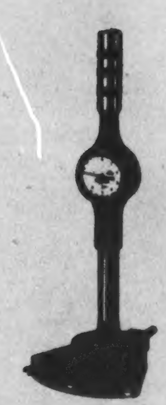


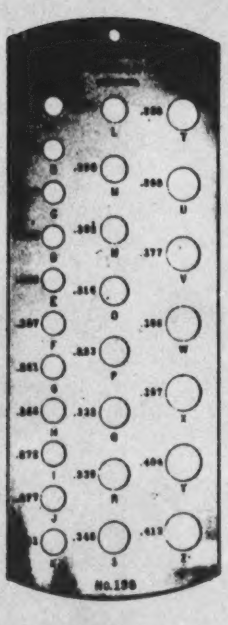


o. ______________________________ p. ______________________________

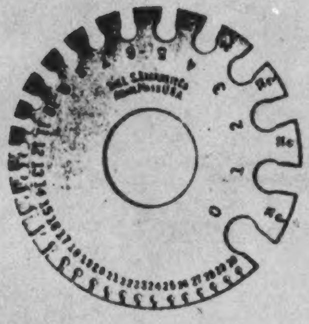


q. ______________________________





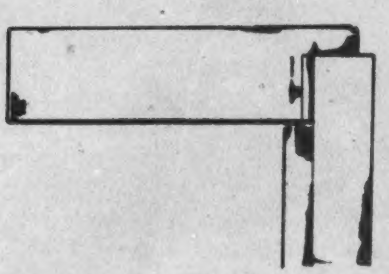
r. ______________________________ s. ______________________________



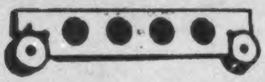
t. ______________________________

3. Identify different inspection tools shown in the following illustrations. Write the correct names in the blanks provided.

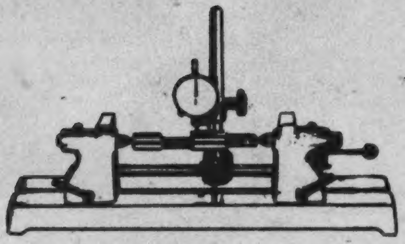
Cylindrical square
Bevel edge steel square
Optical flat
Bench center
Optical comparator
Pressure type air gage
Gage blocks (Johannson or Jo blocks)
Sine bar
Comparator (transfer stand with indicator)
Height micrometer
Electronic comparator

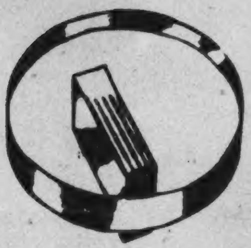


a. ______________________________

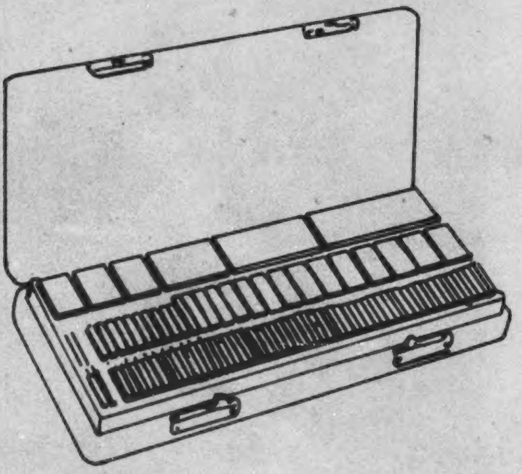


b. ______________________________

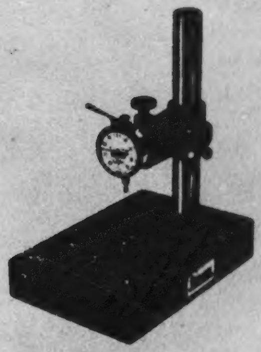




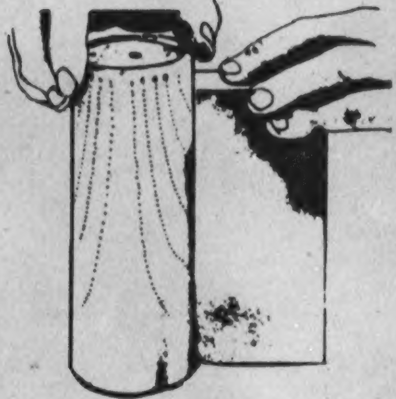
c. ______________________ d. ______________________



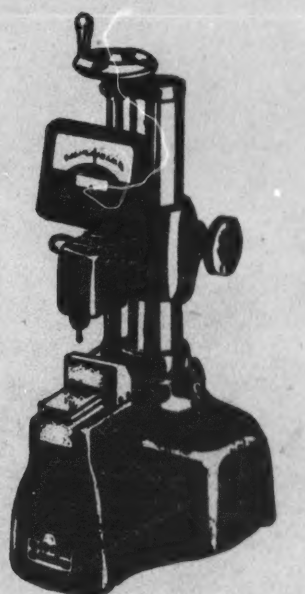
e. ______________________



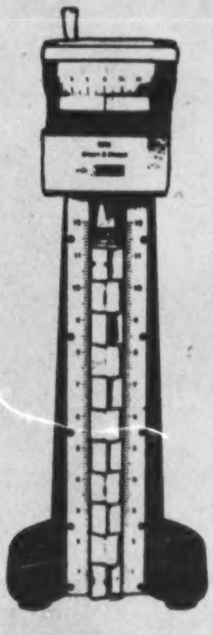
f. ______________________________



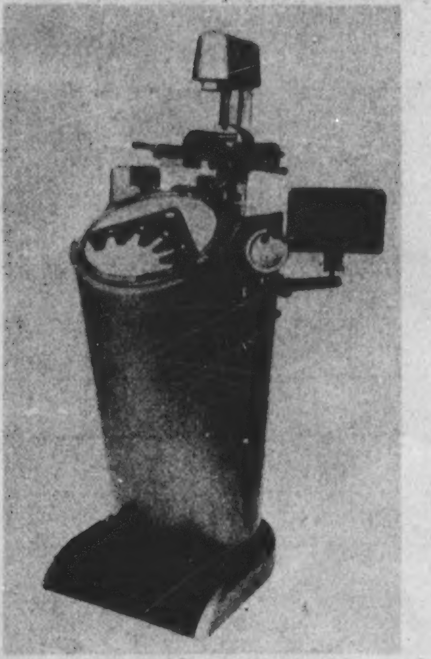
g. ______________________________



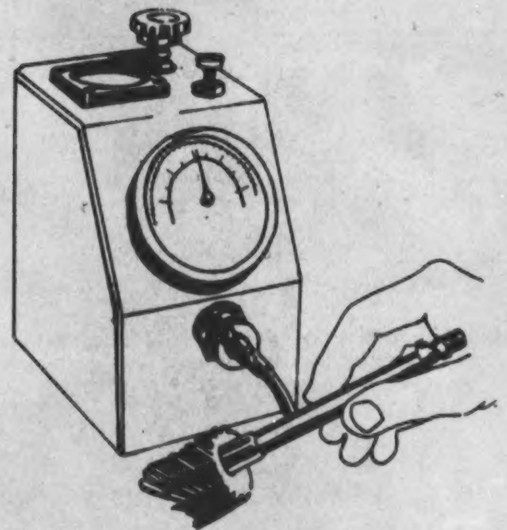
h. ______________________________



i. ______________________________



j. ______________________________



k. ______________________________

4. Describe rules for care of gaging and inspection tools in the blanks below.

   a. Storage-- ____

   ____

   ____

   b. Handling-- ____

   ____

   ____

   c. Cleaning-- ____

   ____

   ____

   d. Inspecting-- ____

   ____

   ____

   e. Lubricating-- ____

   ____

   ____

5. Match gaging tools to their correct uses. Write the correct numbers in the blanks provided. Terms and definitions continue on the next page.

_____a. Used to check 60° threading tool when grinding to shape, to set threading tool when cutting threads, and to check centers

_____b. Used as a fast method of checking the thickness of sheet material

_____c. Used to measure small holes, slots, and grooves by transferring measurements to an outside micrometer; range is 1/8" to 1/2"

_____d. Used to check the bore of parts to .0001 accuracy; must be preset with a ring gage

_____e. Has "go" and "no-go" ends; used to check bore of parts to .0001 accuracy

_____f. Used to check the depth of holes, slots, grooves, and recesses

1. Small hole gage
2. Dial depth gage
3. Dial thickness gage
4. Dial bore gage
5. Cylindrical plug gage
6. Center gage

______g. Used to visually compare the desired finish of a part to a certain known finish

______h. Used to determine the pitch or number of threads per inch of a threaded part

______i. Used to check parts within certain limits of a predetermined, fixed dimension

______j. Used to measure holes, slots, and recesses by transferring measurements to outside micrometer; range is 5/16" to 6"

______k. Has "go" and "no-go" threaded ends; used to check pitch diameter of internal threads

______l. Used to check a radius or fillet

______m. Used to check size of drills and steel wire

______n. Used to check the pitch diameter of a threaded part

______o. Used when drill grinding to determine the correct drill point angle

______p. Used to set, check tools, and measure parts to .0001 accuracy

7. Surface finish gage
8. Drill and steel wire gage
9. Snap gages
10. Drill point gage
11. Radius gage
12. Telescoping gage
13. Thread plug gage
14. Ring gage
15. Thread ring gage
16. Screw pitch gage

6. Match inspection tools to their correct uses. Write the correct numbers in the blanks provided. Terms continue on the next page.

______a. Used to check measurements, set fixed gages, calibrate measuring tools, set comparators, inspect, and perform other set-ups

______b. Used as a visual method of inspection

______c. Used as a master square against which other squares may be checked

______d. Used to inspect size of parts from a flat surface

______e. Used for inspection of parts to a very close tolerance with air flow

______f. Used to inspect parts for squareness

______g. Used to check concentricity of machined parts

______h. Used in inspection of parts; is preset and measures in the millionths of an inch (.000001)

1. Cylindrical square
2. Bevel edge steel square
3. Optical flat
4. Gage blocks
5. Sine bar
6. Bench center
7. Comparator
8. Height micrometer
9. Electronic comparator
10. Pressure type air gage
11. Optical comparator

______i. Uses light waves to measure flatness, parallelism, and size

______j. Used to set up or inspect angular surfaces of 45° or less

______k. Used to set other measuring tools for inspection by comparison; accurate to .0001 of an inch

7. Select the minimum gage blocks required for the settings below. Use the gage block set given and write your answers in the blanks provided.

a. 1.9374 b. 3.0159

FIRST: .0001 Series – 9 Blocks

.1001 .1002 .1003 .1004 .1005 .1006 .1007 .1008 .1009

SECOND: .001 Series – 49 Blocks

.101 .102 .103 .104 .105 .106 .107 .108 .109
.110 .111 .112 .113 .114 .115 .116 .117 .118
.119 .120 .121 .122 .123 .124 .125 .126 .127
.128 .129 .130 .131 .132 .133 .134 .135 .136
.137 .138 .139 .140 .141 .142 .143 .144 .145
.146 .147 .148 .149

THIRD: .050 Series – 19 Blocks

.050 .100 .150 .200 .250 .300 .350 .400 .450 .500
.550 .600 .650 .700 .750 .800 .850 .900 .950

FOURTH: 1.000 Series – 4 Blocks

1.000 2.000 3.000 4.000

TWO .050 WEAR BLOCKS

____________________ ____________________
____________________ ____________________
____________________ ____________________
____________________ ____________________
____________________ ____________________

8. Use trigonometric function tables to calculate sine bar elevations for the following angles when using a 5" sine bar. Write your answers in the blanks provided.

a. 15°0' b. 8°40' c. 23°18'

ans. __________ ans. __________ ans. __________

9. Demonstrate the ability to:

   a. Use gage blocks.

   b. Use sine bar to set angle.

   (NOTE: If the above activities have not been finished before the test, ask your instructor when they should be completed.)

GAGING AND INSPECTION TOOLS
UNIT VII

ANSWERS TO TEST

(NOTE: The point system designated in parentheses is intended to be a guideline and should be adapted as needed. The point total is 275.)

1. (18 points)

   a. 6
   b. 8
   c. 1
   d. 7
   e. 5
   f. 2
   g. 9
   h. 4
   i. 3

2. (40 points)

   a. Snap gage
   b. Thread ring gages
   c. Drill point gage
   d. Ring gages
   e. Dial thickness gage
   f. Radius gages
   g. Screw pitch gages
   h. Dial depth gage
   i. Telescoping gages
   j. Center gage
   k. Cylindrical plug gage
   l. Small hole gages
   m. Fractional drill gage
   n. Number drill gage
   o. Surface finish gage
   p. Snap gage
   q. Thread plug gage
   r. Dial bore gage
   s. Letter drill gage
   t. Steel wire gage

3. (22 points)

   a. Bevel edge steel square
   b. Sine bar
   c. Bench center
   g. Cylindrical square
   h. Electrical comparator
   i. Height micrometer

d. Optical flat

e. Gage blocks

f. Comparator (transfer stand with indicator)

j. Optical comparator

k. Pressure type air gage

4. (25 points)

a. Storage--When you are finished using tools put them up, back in box, or cover with dust cover

b. Handling--Always handle precision tools with care; never throw them around or lay parts on them

c. Cleaning--Wipe tools with a clean rag after using

d. Inspecting--Before using most gages and inspection tools, check them against a standard to be sure of their accuracy

e. Lubricating--Never lubricate plungers of indicators; however, other metal parts should be lubricated with a thin coat of oil to prevent rust

5. (32 points)

a. 6

b. 3

c. 1

d. 4

e. 5

f. 2

g. 7

h. 16

i. 9

j. 12

k. 13

l. 11

m. 8

n. 15

o. 10

p. 14

6. (22 points)

a. 4

b. 11

c. 1

d. 7

e. 10

f. 2

g. 6

h. 9

i. 3

j. 5

k. 8

7. (10 points)

a. .1004
.137
.700
1.000
1.9374

b. .1009
.115
.800
2.000
3.0159

8. (6 points)

a. 1.2941

b. .7534

c. 1.9777

9. (100 points)

Performance skills evaluated to satisfaction of instructor

MATERIALS AND CUTTING FLUIDS
UNIT VIII

UNIT OBJECTIVE

After completion of this unit, the student should be able to select the proper cutting speeds for different materials, and describe the kind of cutting fluid that is best suited for a particular job. This knowledge will be shown by completion of assignment sheets, job sheet, and unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with materials and cutting fluids to the correct definitions.
2. Distinguish between ferrous, non-ferrous, and non-metallic materials.
3. State how different materials affect tool geometry.
4. Identify carbon content of steel from the SAE/AISI numbering systems.
5. Describe factors that affect cutting speeds and tool bit geometry.
6. Match methods for testing for hardness and carbon content of steels to their definitions.
7. Match kinds of cutting fluids to their uses.
8. Describe advantages of using cutting fluids.
9. Describe reasons for using chemical cutting fluids.
10. Demonstrate the ability to perform file and spark test.

MATERIALS AND CUTTING FLUIDS
UNIT VIII

SUGGESTED ACTIVITIES

I. Suggested activities for the instructor:

  A. Order films.

  B. Provide students with objective sheet.

  C. Provide students with information sheet.

  D. Make transparencies.

  E. Discuss objective sheet.

  F. Discuss information sheet.

  G. Provide students with assignment sheets.

  H. Demonstrate different metals and cutting tool materials with Objective V.

  I. Show films on metals and coolants.

  J. Demonstrate and discuss procedures outlined in job sheet.

  K. Cut five metal specimens and mark with SAE numbers. Cut 3 more specimens and mark them "A," "B," and "C."

  Suggested specimens:

  SAE 4140
  SAE 1020
  AISI 316
  SAE 1140
  SAE 1095

  SAE 1140 - A
  SAE 1095 - B
  SAE 4140 - C

  L. Give test.

  M. Reteach and retest if necessary.

II. Instructional materials:

  A. Objective sheet

  B. Information sheet

  C. Transparency masters

    1. TM 1--SAE/AISI Numbering Systems

    2. TM 2--Cutting Speeds (CS)

D. Assignment sheets

  1. Assignment Sheet #1--Distinguish Between Metallic and Non-metallic Materials

  2. Assignment Sheet #2--Interpret SAE/AISI Steel Numbering Systems

E. Answers to assignment sheets

F. Job Sheet #1--Perform File and Spark Test

G. Test

H. Answers to test

III. Unit references:

A. Oberg, Erik, and Jones, F.D. *Machinery's Handbook.* New York: The Industrial Press, 1974.

B. Kibbe, Richard R.; Neely, John E.; Meyer, Roland; and White, Warren T. *Machine Tool Practices.* New York: John Wiley and Sons, 1979.

IV. Films:

A. *Steel and America.* 16mm, 45 min. Available from ARMCO, 703 Curtis, Middletown, OH 45043.

B. *Cool Chip.* 16mm, 18 min. Available from Cincinnati Milacron, Product Division, 4701 Marburg Ave., Cincinnati, OH 45209.

MATERIALS AND CUTTING FLUIDS
UNIT VIII

INFORMATION SHEET

I. Terms and definitions

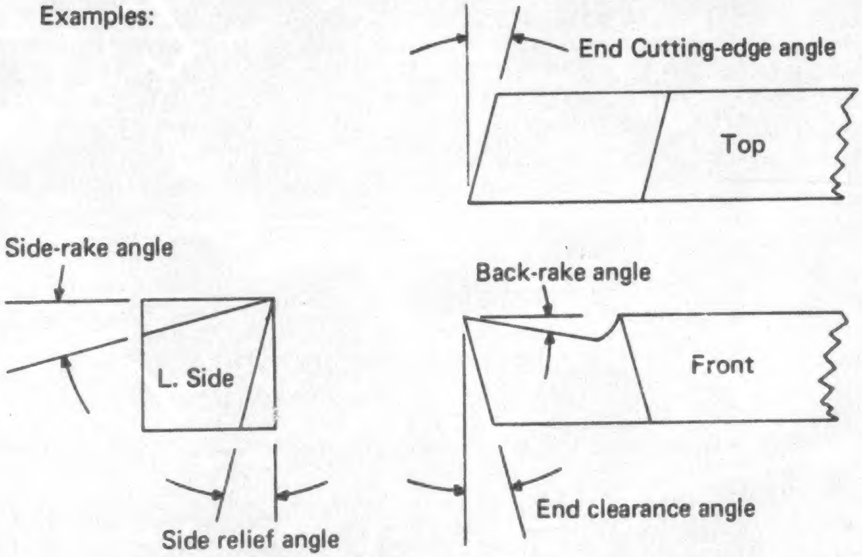
A. Ferrous--Metal with iron as its major element; usually magnetic

B. Non-ferrous--Metal that does not contain iron; not magnetic

C. Tool bit geometry--Angles ground on or angles of cutting tools

(NOTE: These angles will vary with material.)

Examples:


End Cutting-edge angle
Top
Side-rake angle
L. Side
Back-rake angle
Front
Side relief angle
End clearance angle

D. SAE (Society of Automotive Engineers)--Professional group that sets many manufacturing standards

Examples: Steel, screw threads

E. AISI (American Iron and Steel Institute)--Professional group that sets standards for steel

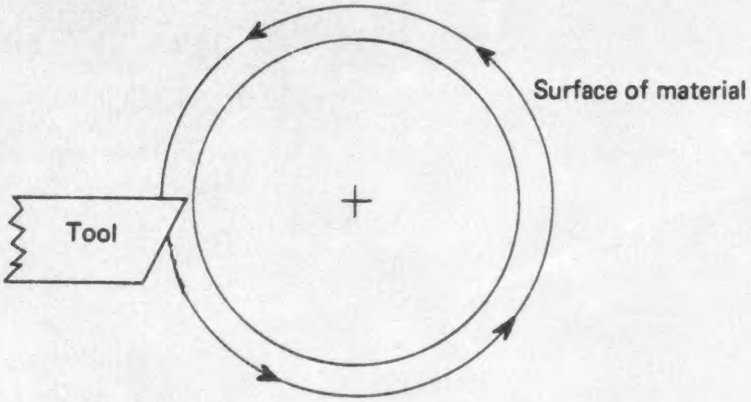
INFORMATION SHEET

F. Cutting speed--Number of feet of material passing the cutting edge per minute

(NOTE: Cutting speed may range from 30-500 feet per minute and will vary with manufacturers' specifications.)

Examples: If the cutting speed is "70," there will be 70 feet of material in contact with the tool every minute

SAE 1140 has a cutting speed of 160; therefore, 160 feet of the material passes the cutting edge of the tool in one minute



G. Metallic--A metal material (ferrous or non-ferrous)

H. Non-metallic--A material without metal

I. Allowable cutting speed--Gives maximum tool life between grindings, with maximum chip or material removal

J. Sour--Having a decayed or rotten smell due to bacterial buildup; caused by contamination

II. Ferrous, non-ferrous, and non-metallic materials (Assignment Sheet #1)

A. Ferrous metals

1. Tool steel
2. Mild steel
3. Cast iron
4. Stainless steel (Type 410)

INFORMATION SHEET

5. High carbon steel
6. Alloy steel

B. Non-ferrous metals

(NOTE: Non-ferrous metals should never be ground with a grinding wheel because the material loads the wheel.)

1. Brass
2. Copper
3. Aluminum
4. Bronze
5. Cast aluminum
6. Lead
7. Stainless steel (Type 316)

C. Non-metallic materials

(NOTE: This list of non-metallic materials is not intended to be complete. Other materials can be added.)

1. Wood
2. Plastic

   Examples: Nylon, Teflon

3. Glass
4. Rubber
5. Ceramic

III. How different materials affect tool geometry -- As a general rule, the softer the metal, the more side clearance and side rake must be ground on the tool so it has a shearing action

(NOTE: Shape of tools, high speed steels, and carbide tools will be discussed in lathes and shapers units.)

IV. SAE/AISI numbering systems (Transparency 1, Assignment Sheet #2)

A. First digit indicates the group of steel

INFORMATION SHEET

B. Second digit indicates the percentage of predominate alloy

Example: SAE Steel Numbering System

Carbon Steels	1xxx
Nonsulfurized Carbon Steels	10xx
Example	1018
Resulfurized Carbon Steels (Free Machining)	11xx
Example	1112
Example	1113
Nickel Steels	2xxx
Nickel (3.25-5.25%)	23xx
Example	2340
Nickle-Chromium Steels	3xxx
1.25% Nickel, 0.65% Chromium	3140
Molybdenum Steels	4xxx
Molybdenum 0.20 or 0.30%	40xx
Example	4024
Chromium Steels	5xxx
Chromium 0.25, 0.40, or 0.50%	50xx
Example (0.25% Chromium, 0.45% Carbon)	5046
Example (1.45% Chromium, 1.00% Carbon)	52100
Chromium-Vanadium Steels	6xxx
Nickel-Chromium-Molybdenum Steels (Nickel less than 1.00%)	8xxx
Silicon-Manganese Steel	92xx
Nickel-Chromium-Molybdenum (Nickel 3.25%)	93xx

C. Third and fourth digits indicate the percent of carbon content

Examples:

SAE 1020	SAE 2517
1xxx--Carbon steel group	2xxx--Nickel steel group
10xx--No alloy ingredient	25xx--5% nickel alloy
1020--.20 of 1% carbon content	2517--.17 of 1% carbon content

INFORMATION SHEET

(NOTE: The only difference between the SAE and AISI numbering systems is the letter that precedes the AISI number. For example, in the number E2517, E denotes electric furnace, A denotes open hearth, B denotes acid bessemer, C denotes basic open hearth, and D denotes acid open hearth.)

V. Factors that affect cutting speeds and tool bit geometry (Transparency 2)

A. Machinability of material--How hard or easy a material is to cut

B. Hardness of material--Resistance to penetration

C. Toughness of material--Resistance to cutting

VI. Testing for hardness and carbon content of steels

A. File test--Test where metal is filed and ease or difficulty is noted

(NOTE: Compare different tests in the chart below. Notice that materials that are above 30 to 42 Rockwell "C" are almost impossible or impractical to machine with high speed steel.)

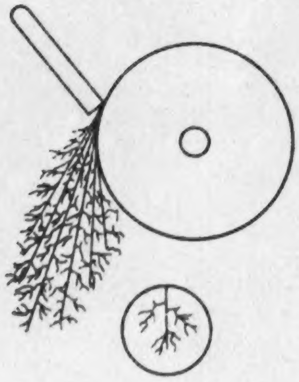
File Test and Hardness Table

	Rockwell			
File Reaction	**B**	**C**	**Brinell**	**Type Steel**
File bites easily into metal	65		100	Mild steel
File bites into metal with pressure		16	212	Medium carbon steel
File does not bite into metal except with difficulty		31	294	High alloy steel High carbon steel
Metal can only be filed with extreme pressure		42	390	Tool steel
File will mark metal but metal is nearly as hard as the file and filing is impractical		50	481	Hardened tool steel
Metal is as hard as the file		64	739	Case hardened parts

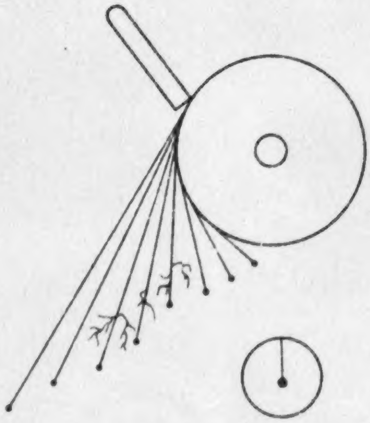
INFORMATION SHEET

B. Spark test--Test where metal displays a particular spark pattern when held against a grinding wheel; sparks are compared with known sample

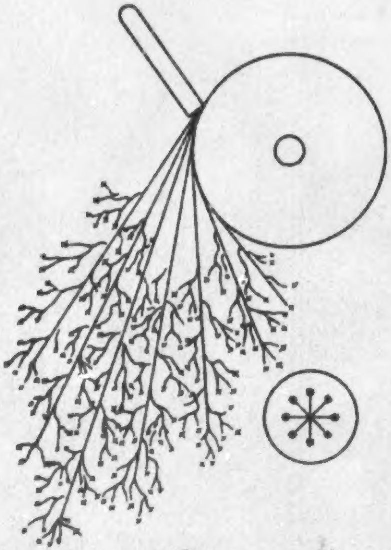
Examples:



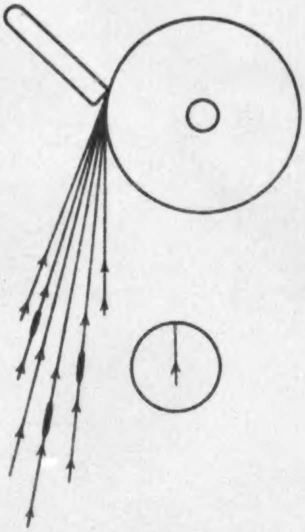
Cast iron. Short carrier lines with many bursts, which are red near the grinder and orange-yellow further out. Considerable pressure is required on cast iron to produce sparks.



High speed steel. Carrier lines are orange, ending in pear-shaped globules with very little branching or carbon sparks. High speed steel requires moderate pressure to produce sparks.



High carbon steel. Short, very white or light yellow carrier lines with considerable forking, having many starlike bursts. Many of the sparks follow around the wheel.



Low carbon steel. Straight carrier lines having a yellowish color with very small amount of branching and very few carbon bursts.

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INFORMATION SHEET

C. Rockwell test--Test for hardness of materials; uses a carbide ball (B scale) or a cone-shaped diamond penetrator (C scale); measures depth of penetration and converts this to a standard scale; primarily used for inspection, but can be used to check for machinability

D. Brinell test--Uses a ball penetrator to create impression on metal; diameter of impression is measured and converted mathematically

(NOTE: In the table below, a Brinell test reading of 653 is equal to a Rockwell test reading of 60 C.)

Hardness and Tensile Strength Comparison Table

Hardness Conversion Table

Brinell		Rockwell		Tensile Strength, 1000 psi Approximately	Brinell		Rockwell		Tensile Strength, 1000 psi Approximately
Indentation diameter, mm	No.*	B	C		Indentation diameter, mm	No.*	B	C	
2.25	745		65.3		3.75	262	(103.0)	26.6	127
2.30	712		–		3.80	255	(102.0)	25.4	123
2.35	682		61.7		3.85	248	(101.0)	24.2	120
2.40	653		60.0		3.90	241	100.0	22.8	116
2.45	627		58.7		3.95	235	99.0	21.7	114
2.50	601		57.3		4.00	229	98.2	20.5	111
2.55	578		56.0		4.05	223	97.3	(18.8)	–
2.60	555		54.7	298	4.10	217	96.4	(17.5)	105
2.65	534		53.5	288	4.15	212	95.5	(16.0)	102
2.70	514		52.1	274	4.20	207	94.6	(15.2)	100
2.75	495		51.6	269	4.25	201	93.8	(13.8)	98
2.80	477		50.3	258	4.30	197	92.8	(12.7)	95
2.85	461		48.8	244	4.35	192	91.9	(11.5)	93
2.90	444		47.2	231	4.40	187	90.7	(10.0)	90
2.95	429		45.7	219	4.45	183	90.0	(9.0)	89
3.00	415		44.5	212	4.50	179	89.0	(8.0)	87
3.05	401		43.1	202	4.55	174	87.8	(6.4)	85
3.10	388		41.8	193	4.60	170	86.8	(5.4)	83
3.15	375		40.4	184	4.65	167	86.0	(4.4)	81
3.20	363		39.1	177	4.70	163	85.0	(3.3)	79
3.25	352	(110.0)	37.9	171	4.80	156	82.9	(0.9)	76
3.30	341	(109.0)	36.6	164	4.90	149	80.8		73
3.35	331	(108.5)	35.5	159	5.00	143	78.7		71
3.40	321	(108.0)	34.3	154	5.10	137	76.4		67
3.45	311	(107.5)	33.1	149	5.20	131	74.0		65
3.50	302	(107.0)	32.1	146	5.30	126	72.0		63
3.55	293	(106.0)	30.9	141	5.40	121	69.8		60
3.60	285	(105.5)	29.9	138	5.50	116	67.6		58
3.65	277	(104.5)	28.8	134	5.60	111	65.7		56
3.70	269	(104.0)	27.6	130					

Note 1. This is a condensation of Table 2, Report J417b, SAE 1971 Handbook. Values in ( ) are beyond normal range, and are presented for information only.

*Values above 500 are for tungsten carbide ball; below 500 for standard ball.

Note 2. The following is a formula to approximate tensile strength when the Brinell hardness is known:

Tensile strength = *BHN* × 500

Source. Bethlehem Steel Corporation, *Modern Steels and Their Properties*, Seventh Edition, Handbook 2757, 1972.

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INFORMATION SHEET

VII. Kinds of cutting fluids and their uses

A. Light and dark cutting oils--Used when cooling work and when there is high chip-bearing pressure, as in machining alloy or other tough steels

B. Emulsifying or soluble oils--Mix with water; used when cooling work and tool with light lubricating action; wash chips from work

C. Chemical emulsions--Used to cool work and tool, improve finish, wash chips from work; contain no oil

D. Chemical cutting fluids--Used when tapping or drilling by hand

(NOTE: These come in pressurized spray cans.)

VIII. Advantages of using cutting fluids

A. Take the heat away from the part

B. Prolong the life of the cutting edge of the tool

C. Help in chip control by washing chips away from cutter

D. Help in obtaining desired finish on part

E. Help in machining parts to size by keeping part cool

F. Help lubricate machine parts

IX. Reasons for using chemical cutting fluids

A. Will not sour as fast as soluble oils due to lack of bacteria-forming agents

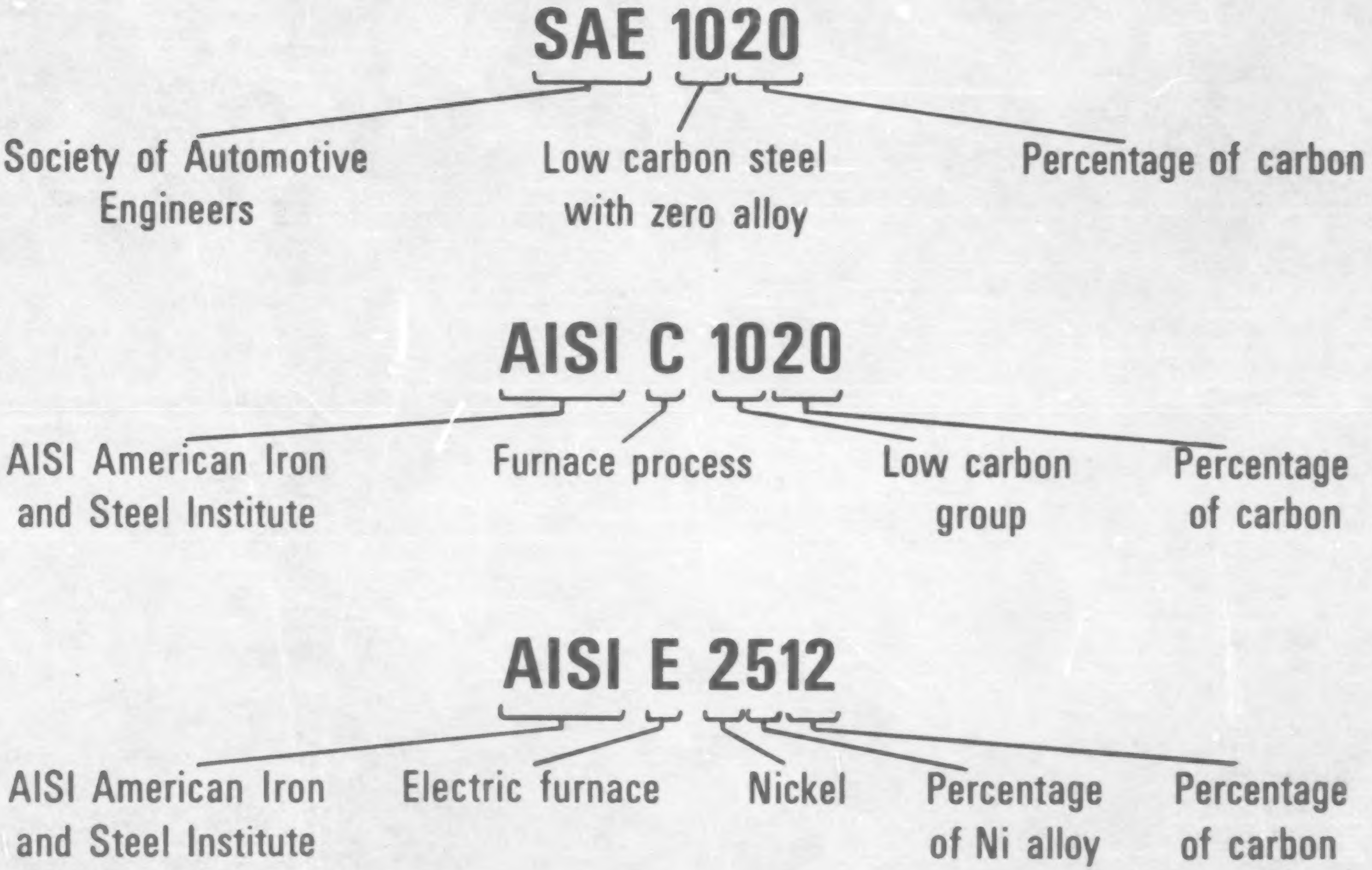
B. Are anti-allergenic

C. Are easy to clean

D. Do not stain machine

E. Are not irritating to nose and throat

SAE/AISI Numbering Systems



SAE 1020

Society of Automotive Engineers

Low carbon steel with zero alloy

Percentage of carbon

AISI C 1020

AISI American Iron and Steel Institute

Furnace process

Low carbon group

Percentage of carbon

AISI E 2512

AISI American Iron and Steel Institute

Electric furnace

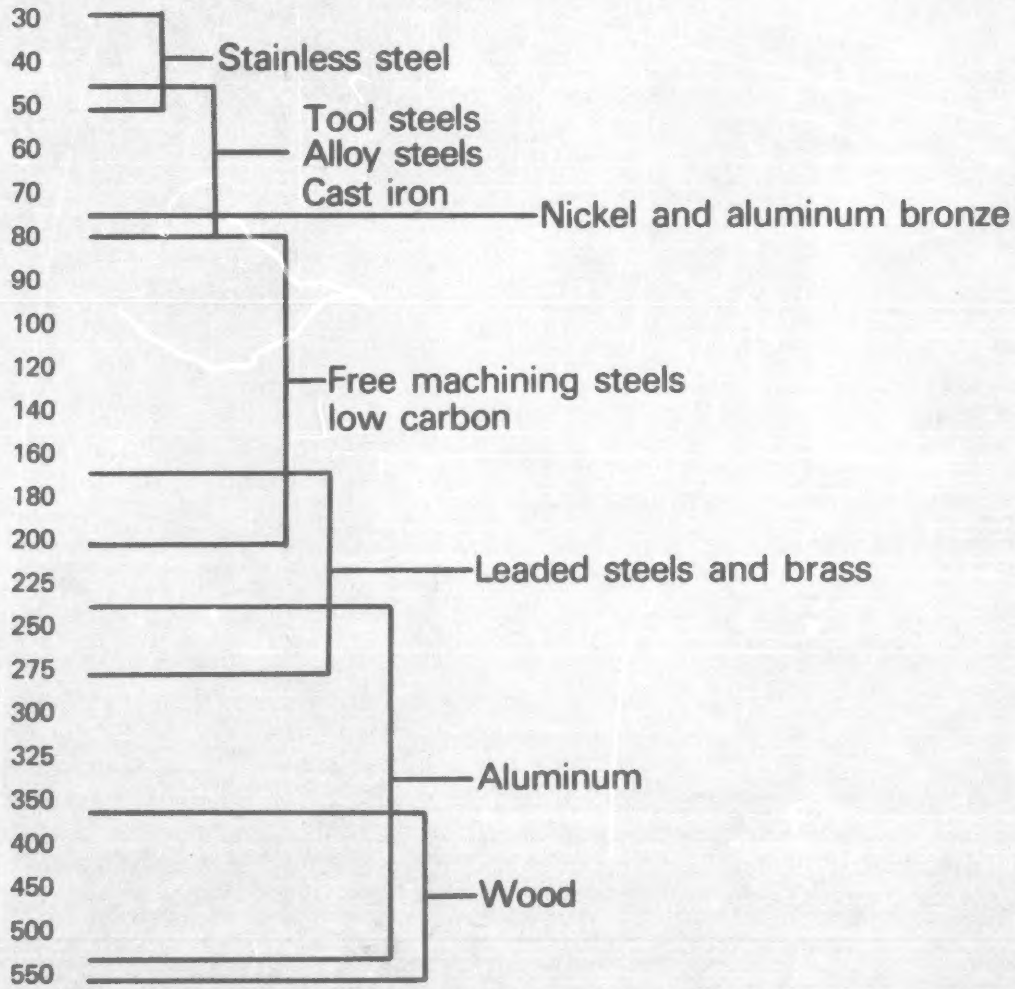
Nickel

Percentage of Ni alloy

Percentage of carbon

Cutting Speeds (CS)

SFM (Surface Feet per Minute)


30
40
50
60
70
80
90
100
120
140
160
180
200
225
250
275
300
325
350
400
450
500
550
Stainless steel
Tool steels
Alloy steels
Cast iron
Nickel and aluminum bronze
Free machining steels
low carbon
Leaded steels and brass
Aluminum
Wood

(NOTE: This range is for High Speed Steel [H.S S.]. When using carbides, the cutting speed is three times that of H.SS.)

MATERIALS AND CUTTING FLUIDS
UNIT VIII

ASSIGNMENT SHEET #1--DISTINGUISH BETWEEN METALLIC AND NON-METALLIC MATERIALS

NAME ______________________________ SCORE __________

Knowledge of types of materials helps you set the machine at the right rpm and select the proper tools to make the part.

Distinguish between each of the following metals as ferrous, non-ferrous, or non-metallic by writing the correct class for each metal listed.

A. Mild steel ______________________________

B. Lead ______________________________

C. Wood ______________________________

D. Brass ______________________________

E. Aluminum ______________________________

F. Rubber ______________________________

G. Stainless steel ______________________________

H. Plastic ______________________________

I. Tool steel ______________________________

J. Copper ______________________________

K. Ceramic ______________________________

L. High carbon steel ______________________________

M. Cast aluminum ______________________________

N. Alloy steel ______________________________

O. Bronze ______________________________

MATERIALS AND CUTTING FLUIDS
UNIT VIII

ASSIGNMENT SHEET #2--INTERPRET SAE/AISI STEEL NUMBERING SYSTEMS

NAME____ SCORE ____________

Knowing the carbon content and other alloying agents of steel helps in determining tool selection, rpm, and feed.

Use the tables on the next pages to list the carbon content of each steel listed below and the approximate cutting speed (CS) for finishing.

Steel	Carbon Content	Cutting Speed (CS)
AISI 4140		
SAE 5120		
SAE 1020		
AISI C 1095		
AISI C 1120		
SAE 3145		
SAE 4140		
AISI 303		
SAE 51420F		

ASSIGNMENT SHEET #2

SAE STANDARD STEELS

Chemical Compositions of SAE Standard Steels–1

These compositions are applicable either to open-hearth or electric furnace steels. For the latter, the maximum phosphorus and sulphur content is 0.025 per cent. The nominal chemical limits or ranges in the compositions on pages 1, 2, 3, and 4 of this table are subject to standard variations in check analysis. New SAE numbers without prefixes are now used to replace numbers such as X1015, X1020, etc.

SAE Number	AISI Number*	Carbon C	Manganese Mn	Phosphorus P (Max.)	Sulphur S (Max.)
SAE IXX = CARBON STEELS					
1006	C1006	0.08 max.	0.25-0.40	0.040	0.050
1008	C1008	0.10 max.	0.25-0.50	0.040	0.050
1010	C1010	0.08-0.13	0.30-0.60	0.040	0.050
1015	C1015	0.13-0.18	0.30-0.60	0.040	0.050
1016	C1016	0.13-0.18	0.60-0.90	0.040	0.050
1017	C1017	0.15-0.20	0.30-0.60	0.040	0.050
1018	C1018	0.15-0.20	0.60-0.90	0.040	0.050
1019	C1019	0.15-0.20	0.70-1.00	0.040	0.050
1020	C1020	0.18-0.23	0.30-0.60	0.040	0.050
1021	C1021	0.18-0.23	0.60-0.90	0.040	0.050
1022	C1022	0.18-0.23	0.70-1.00	0.040	0.050
1024	C1024	0.19-0.25	1.35-1.65	0.040	0.050
1025	C1025	0.22-0.28	0.30-0.60	0.040	0.050
1026	C1026	0.22-0.28	0.60-0.90	0.040	0.050
1027	C1027	0.22-0.29	1.20-1.50	0.040	0.050
1030	C1030	0.28-0.34	0.60-0.90	0.040	0.050
1033	C1033	0.30-0.36	0.70-1.00	0.040	0.050
1034	C1034	0.32-0.38	0.50-0.80	0.040	0.050
1035	C1035	0.32-0.38	0.60-0.90	0.040	0.050
1036	C1036	0.30-0.37	1.20-1.50	0.040	0.050
1038	C1038	0.35-0.42	0.60-0.90	0.040	0.050
1039	C1039	0.37-0.44	0.70-1.00	0.040	0.050
1040	C1040	0.37-0.44	0.60-0.90	0.040	0.050
1041	C1041	0.36-0.44	1.35-1.65	0.040	0.050
1042	C1042	0.40-0.47	0.60-0.90	0.040	0.050
1043	C1043	0.40-0.47	0.70-1.00	0.040	0.050
1045	C1045	0.43-0.50	0.60-0.90	0.040	0.050
1046	C1046	0.43-0.50	0.70-1.00	0.040	0.050
1049	C1049	0.46-0.53	0.60-0.90	0.040	0.050
1050	C1050	0.48-0.55	0.60-0.90	0.040	0.050
1052	C1052	0.47-0.55	1.20-1.50	0.040	0.050
1055	C1055	0.50-0.60	0.60-0.90	0.040	0.050
1060	C1060	0.55-0.65	0.60-0.90	0.040	0.050
1062	C1062	0.54-0.65	0.85-1.15	0.040	0.050
1064	C1064	0.60-0.70	0.50-0.80	0.040	0.050
1065	C1065	0.60-0.70	0.60-0.90	0.040	0.050
1066	C1066	0.60-0.71	0.85-1.15	0.040	0.050
1070	C1070	0.65-0.75	0.60-0.90	0.040	0.050
1074	C1074	0.70-0.80	0.50-0.80	0.040	0.050
1078	C1078	0.72-0.85	0.30-0.60	0.040	0.050
1080	C1080	0.75-0.88	0.60-0.90	0.040	0.050
1085	C1085	0.80-0.93	0.70-1.00	0.040	0.050
1086	C1086	0.82-0.95	0.30-0.50	0.040	0.050
1090	C1090	0.85-0.98	0.60-0.90	0.040	0.050
1095	C1095	0.90-1.03	0.30-0.50	0.040	0.050
SAE IIXX = FREE-CUTTING STEELS					
Bessemer					
† 1111	B1111	0.13 max.	0.60-0.90	0.07-0.12	0.08-0.15
† 1112	B1112	0.13 max.	0.70-1.00	0.07-0.12	0.16-0.23
† 1113	B1113	0.13 max.	0.70-1.00	0.07-0.12	0.24-0.33

* American Iron and Steel Institute.

† Because of the nature of the process, acid bessemer steels are not furnished with specified silicon content.

ASSIGNMENT SHEET #2

SAE STANDARD STEELS

Chemical Compositions of SAE Standard Steels--2

SAE Number	AISI Number*	Carbon C	Manganese Mn	Phosphorus P (Max.)	Sulphur S
FREE-CUTTING STEELS (Continued)					
Open Hearth					
1109	C1109	0.08-0.13	0.60-0.90	0.040	0.08-0.13
1114	C1114	0.10-1.16	1.00-1.30	0.040	0.08-0.13
1115	C1115	0.13-0.18	0.60-0.90	0.040	0.08-0.13
1116	C1116	0.14-0.20	1.10-1.40	0.040	0.16-0.23
1117	C1117	0.14-0.20	1.00-1.30	0.040	0.08-0.13
1118	C1118	0.14-0.20	1.30-1.60	0.040	0.08-0.13
1119	C1119	0.14-0.20	1.00-1.30	0.040	0.24-0.33
1120	C1120	0.18-0.23	0.70-1.00	0.040	0.08-0.13
1126	C1126	0.23-0.29	0.70-1.00	0.040	0.08-0.13
1132	C1132	0.27-0.34	1.35-1.65	0.040	0.08-0.13
1137	C1137	0.32-0.39	1.35-1.65	0.040	0.08-0.13
1138	C1138	0.34-0.40	0.70-1.00	0.040	0.08-0.13
1140	C1140	0.37-0.44	0.70-1.00	0.040	0.08-0.13
1141	C1141	0.37-0.45	1.35-1.65	0.040	0.08-0.13
1144	C1144	0.40-0.48	1.35-1.65	0.040	0.24-0.33
1145	C1145	0.42-0.49	0.70-1.00	0.040	0.04-0.07
1146	C1146	0.42-0.49	0.70-1.00	0.040	0.08-0.13
1151	C1151	0.48-0.55	0.70-1.00	0.040	0.08-0.13

SAE Number	AISI Number*	Carbon C	Manganese Mn	Nickel Ni	Chromium Cr	Phos. P (Max.)	Sulphur S (Max.)
MANGANESE STEELS†							
1320	1320	0.18-0.23	1.60-1.90	....	....	0.040	0.040
1330	1330	0.28-0.33	1.60-1.90	....	....	0.040	0.040
1335	1335	0.33-0.38	1.60-1.90	....	....	0.040	0.040
1340	1340	0.38-0.43	1.60-1.90	....	....	0.040	0.040
SAE 2XXX = NICKEL STEELS†							
2317	2317	0.15-0.20	0.40-0.60	3.25-3.75	....	0.040	0.040
2330	2330	0.28-0.33	0.60-0.80	3.25-3.75	....	0.040	0.040
2340	2340	0.38-0.43	0.70-0.90	3.25-3.75	....	0.040	0.040
2345	2345	0.43-0.48	0.70-0.90	3.25-3.75	....	0.040	0.040
2512	E2512	0.09-0.14	0.45-0.60	4.75-5.25	....	0.025	0.025
2515	2515	0.12-0.17	0.40-0.60	4.75-5.25	....	0.040	0.040
2517	E2517	0.15-0.20	0.45-0.60	4.75-5.25	....	0.025	0.025
SAE 3XXX = NICKEL-CHROMIUM STEELS†							
3115	3115	0.13-0.18	0.40-0.60	1.10-1.40	0.55-0.75	0.040	0.040
3120	3120	0.17-0.22	0.60-0.80	1.10-1.40	0.55-0.75	0.040	0.040
3130	3130	0.28-0.33	0.60-0.80	1.10-1.40	0.55-0.75	0.040	0.040
3135	3135	0.33-0.38	0.60-0.80	1.10-1.40	0.55-0.75	0.040	0.040
3140	3140	0.38-0.43	0.70-0.90	1.10-1.40	0.55-0.75	0.040	0.040
3141	3141	0.38-0.43	0.70-0.90	1.10-1.40	0.70-0.90	0.040	0.040
3145	3145	0.43-0.48	0.70-0.90	1.10-1.40	0.70-0.90	0.040	0.040
3150	3150	0.48-0.53	0.70-0.90	1.10-1.40	0.70-0.90	0.040	0.040
3310	E3310	0.08-0.13	0.45-0.60	3.25-3.75	1.40-1.75	0.025	0.025
3316	E3316	0.14-0.19	0.45-0.60	3.25-3.75	1.40-1.75	0.025	0.025

* American Iron and Steel Institute. The letter E, where used, indicates an electric furnace steel. AISI number without prefix indicates steel is predominately open hearth.

† Silicon content 0.20-0.35 percent.

ASSIGNMENT SHEET #2

SAE STANDARD STEELS

Chemical Compositions of SAE Standard Steels--3

SAE Number	AISI Number*	Carbon C	Manganese Mn	Nickel Ni	Chromium Cr	Moly. Mo
SAE 4XXX = MOLYBDENUM STEELS†						
4017	4017	0.15-0.20	0.70-0.90	....	....	0.20-0.30
4023	4023	0.20-0.25	0.70-0.90	....	....	0.20-0.30
4024	4024	0.20-0.25	0.70-0.90	....	....	0.20-0.30
4027	4027	0.25-0.30	0.70-0.90	....	....	0.20-0.30
4028	4028	0.25-0.30	0.70-0.90	....	....	0.20-0.30
4032	4032	0.30-0.35	0.70-0.90	....	....	0.20-0.30
4037	4037	0.35-0.40	0.70-0.90	....	....	0.20-0.30
4042	4042	0.40-0.45	0.70-0.90	....	....	0.20-0.30
4047	4047	0.45-0.50	0.70-0.90	....	....	0.20-0.30
4053	4053	0.50-0.56	0.75-1.00	....	....	0.20-0.30
4063	4063	0.60-0.67	0.75-1.00	....	....	0.20-0.30
4068	4068	0.63-0.70	0.75-1.00	....	....	0.20-0.30
4119	......	0.17-0.22	0.70-0.90	....	0.40-0.60	0.20-0.30
4125	......	0.23-0.28	0.70-0.90	....	0.40-0.60	0.20-0.30
4130	4130	0.28-0.33	0.40-0.60	....	0.80-1.10	0.15-0.25
4137	4137	0.35-0.40	0.70-0.90	....	0.80-1.10	0.15-0.25
4140	4140	0.38-0.43	0.75-1.00	....	0.80-1.10	0.15-0.25
4145	4145	0.43-0.48	0.75-1.00	....	0.80-1.10	0.15-0.25
4150	4150	0.48-0.53	0.75-1.00	....	0.80-1.10	0.15-0.25
4317	4317	0.15-0.20	0.45-0.65	1.65-2.00	0.40-0.60	0.20-0.30
4320	4320	0.17-0.22	0.45-0.65	1.65-2.00	0.40-0.60	0.20-0.30
4340	4340	0.38-0.43	0.60-0.80	1.65-2.00	0.70-0.90	0.20-0.30
4608	4608	0.06-0.11	0.25-0.45	1.40-1.75	....	0.15-0.25
4615	4615	0.13-0.18	0.45-0.65	1.65-2.00	....	0.20-0.30
4617	......	0.15-0.20	0.45-0.65	1.65-2.00	....	0.20-0.30
4620	4620	0.17-0.22	0.45-0.65	1.65-2.00	....	0.20-0.30
X4620	......	0.18-0.23	0.50-0.70	1.65-2.00	....	0.20-0.30
4621	4621	0.18-0.23	0.70-0.90	1.65-2.00	....	0.20-0.30
4640	4640	0.38-0.43	0.60-0.80	1.65-2.00	....	0.20-0.30
4812	4812	0.10-0.15	0.40-0.60	3.25-3.75	....	0.20-0.30
4815	4815	0.13-0.18	0.40-0.60	3.25-3.75	....	0.20-0.30
4817	4817	0.15-0.20	0.40-0.60	3.25-3.75	....	0.20-0.30
4820	4820	0.18-0.23	0.50-0.70	3.25-3.75	....	0.20-0.30
SAE 5XXX = CHROMIUM STEELS†						
5045	5045	0.43-0.48	0.70-0.90	....	0.55-0.75	....
5046	5046	0.43-0.50	0.75-1.00	....	0.20-0.35	....
5115	......	0.13-0.18	0.70-0.90	....	0.70-0.90	....
5120	5120	0.17-0.22	0.70-0.90	....	0.70-0.90	....
5130	5130	0.28-0.33	0.70-0.90	....	0.80-1.10	....
5132	5132	0.30-0.35	0.60-0.80	....	0.75-1.00	....
5135	5135	0.33-0.38	0.60-0.80	....	0.80-1.05	....
5140	5140	0.38-0.43	0.70-0.90	....	0.70-0.90	....
5145	5145	0.43-0.48	0.70-0.90	....	0.70-0.90	....
5147	5147	0.45-0.52	0.70-0.95	....	0.85-1.15	....
5150	5150	0.48-0.53	0.70-0.90	....	0.70-0.90	....
5152	5152	0.48-0.55	0.70-0.90	....	0.90-1.20	....
5160	5160	0.55-0.65	0.75-1.00	....	0.70-0.90	....
50100	E50100	0.95-1.10	0.25-0.45	....	0.40-0.60	....
51100	E51100	0.95-1.10	0.25-0.45	....	0.90-1.15	....
52100	E52100	0.95-1.10	0.25-0.45	....	1.30-1.60	....

* American Iron and Steel Institute. The letter E, where used, indicates an electric furnace steel. AISI number without prefix indicates steel is predominately open hearth.

† Silicon content 0.20-0.35 percent except for SAE 4608 which is 0.25 percent max. Maximum sulphur and phosphorus contents are 0.040 percent each except for SAE 4024 and 4028 which have 0.035 to 0.050 percent sulphur, and SAE 50100, 51100, and 52100 which have 0.025 percent, max. sulphur and phosphorus.

ASSIGNMENT SHEET #2

SAE STANDARD STEELS

Chemical Compositions of SAE Standard Steels–4

SAE Number	AISI Number*	Carbon C	Manganese Mn	Silicon Si	Chromium Cr	Vanadium V Min.
SAE 6XXX = CHROMIUM VANADIUM STEEL**						
6150	6150	0.48-0.53	0.70-0.90	0.20-0.35	0.80-1.10	0.15
SAE 92XX = SILICON MANGANESE STEELS**						
9254	......	0.50-0.60	0.50-0.80	1.20-1.60	0.50-0.80	....
9255	9255	0.50-0.60	0.70-0.95	1.80-2.20	....	....
9260	9260	0.55-0.65	0.70-1.00	1.80-2.20	....	....
9261	9261	0.55-0.65	0.75-1.00	1.80-2.20	0.10-0.25	....
9262	9262	0.55-0.65	0.75-1.00	1.80-2.20	0.25-0.40	....
SAE Number	AISI Number*	Carbon C	Manganese Mn	Nickel Ni	Chromium Cr	Moly. Mo
SAE 8XXX = TRIPLE ALLOY STEELS**						
8615	8615	0.13-0.18	0.70-0.90	0.40-0.70	0.40-0.60	0.15-0.25
8617	8617	0.15-0.20	0.70-0.90	0.40-0.70	0.40-0.60	0.15-0.25
8620	8620	0.18-0.23	0.70-0.90	0.40-0.70	0.40-0.60	0.15-0.25
8622	8622	0.20-0.25	0.70-0.90	0.40-0.70	0.40-0.60	0.15-0.25
8625	8625	0.23-0.28	0.70-0.90	0.40-0.70	0.40-0.60	0.15-0.25
8627	8627	0.25-0.30	0.70-0.90	0.40-0.70	0.40-0.60	0.15-0.25
8630	8630	0.28-0.33	0.70-0.90	0.40-0.70	0.40-0.60	0.15-0.25
8632	8632	0.30-0.35	0.70-0.90	0.40-0.70	0.40-0.60	0.15-0.25
8635	8635	0.33-0.38	0.75-1.00	0.40-0.70	0.40-0.60	0.15-0.25
8637	8637	0.35-0.40	0.75-1.00	0.40-0.70	0.40-0.60	0.15-0.25
8640	8640	0.38-0.43	0.75-1.00	0.40-0.70	0.40-0.60	0.15-0.25
8641	8641	0.38-0.43	0.75-1.00	0.40-0.70	0.40-0.60	0.15-0.25
8642	8642	0.40-0.45	0.75-1.00	0.40-0.70	0.40-0.60	0.15-0.25
8645	8645	0.43-0.48	0.75-1.00	0.40-0.70	0.40-0.60	0.15-0.25
8647	8647	0.45-0.50	0.75-1.00	0.40-0.70	0.40-0.60	0.15-0.25
8650	8650	0.48-0.53	0.75-1.00	0.40-0.70	0.40-0.60	0.15-0.25
8653	8653	0.50-0.56	0.75-1.00	0.40-0.70	0.50-0.80	0.15-0.25
8655	8655	0.50-0.60	0.75-1.00	0.40-0.70	0.40-0.60	0.15-0.25
8660	8660	0.55-0.65	0.75-1.00	0.40-0.70	0.40-0.60	0.15-0.25
8719	8719	0.18-0.23	0.60-0.80	0.40-0.70	0.40-0.60	0.20-0.30
8720	8720	0.18-0.23	0.70-0.90	0.40-0.70	0.40-0.60	0.20-0.30
8735	8735	0.33-0.38	0.75-1.00	0.40-0.70	0.40-0.60	0.20-0.30
8740	8740	0.38-0.43	0.75-1.00	0.40-0.70	0.40-0.60	0.20-0.30
8745	8745	0.43-0.48	0.75-1.00	0.40-0.70	0.40-0.60	0.20-0.30
8750	8750	0.48-0.53	0.75-1.00	0.40-0.70	0.40-0.60	0.20-0.30
9310	E9310	0.08-0.13	0.45-0.65	3.00-3.50	1.00-1.40	0.08-0.15
9315	E9315	0.13-0.18	0.45-0.65	3.00-3.50	1.00-1.40	0.08-0.15
9317	E9317	0.15-0.20	0.45-0.65	3.00-3.50	1.00-1.40	0.08-0.15
9437	9437	0.35-0.40	0.90-1.20	0.30-0.60	0.30-0.50	0.08-0.15
9440	9440	0.38-0.43	0.90-1.20	0.30-0.60	0.30-0.50	0.08-0.15
9442	9442	0.40-0.45	1.00-1.30	0.30-0.60	0.30-0.50	0.08-0.15
9445	9445	0.43-0.48	1.00-1.30	0.30-0.60	0.30-0.50	0.08-0.15

* American Iron and Steel Institute. The letter E, where used, indicates an electric furnace steel. AISI number without prefix indicates steel is predominately open hearth.

** Maximum sulphur and phosphorus contents 0.040 percent each, except for SAE 8641 which has 0.040 to 0.060 percent sulphur and SAE 9310, 9315, and 9317, which have 0.025 percent each of sulphur and phosphorus. Except for silicon-manganese steels, silicon content is 0.20-0.35 percent.

ASSIGNMENT SHEET #2

SAE STANDARD STEELS

Chemical Compositions of SAE Standard Steels--5

SAE Number	AISI Number*	Carbon C	Manganese Mn	Nickel Ni	Chromium Cr	Moly. Mo
TRIPLE ALLOY STEELS** (Continued)						
9747	9747	0.45-0.50	0.50-0.80	0.40-0.70	0.10-0.25	0.15-0.25
9763	9763	0.60-0.67	0.50-0.80	0.40-0.70	0.10-0.25	0.15-0.25
9840	9840	0.38-0.43	0.70-0.90	0.85-1.15	0.70-0.90	0.20-0.30
9845	9845	0.43-0.48	0.70-0.90	0.85-1.15	0.70-0.90	0.20-0.30
9850	9850	0.48-0.53	0.70-0.90	0.85-1.15	0.70-0.90	0.20-0.30

SAE Number†	AISI Type*	Carbon C	Manganese Mn Max.	Chromium Cr	Nickel Ni	Other Elements
WROUGHT CHROMIUM NICKEL AUSTENITIC STEELS†† (Not capable of heat treatment)						
30301	301	0.08-0.15	2.00	16.00-18.00	6.00-8.00	....
30302	302	0.08-0.15	2.00	17.00-19.00	7.00-10.00	....
30303F	303	0.15 max.	2.00	17.00-19.00	8.00-10.00	P, S, Se, Min. 0.07; Zr, Mo, Max. 0.60
30304	304	0.08 max.	2.00	18.00-20.00	8.00-11.00	....
30305	305	0.12 max.	2.00	17.00-19.00	10.00-13.00	....
30309	309	0.20 max.	2.00	22.00-24.00	12.00-15.00	....
30310	310	0.25 max.	2.00	24.00-26.00	19.00-22.00	....
30316	316	0.08 max.	2.00	16.00-18.00	10.00-14.00	Mo 2.00-3.00
30317	317	0.08 max.	2.00	18.00-20.00	11.00-15.00	Mo 3.00-4.00
30321	321	0.08 max.	2.50	17.00-19.00	8.00-12.00	Min. Ti = 5 x C
30325	325	0.25 max.	0.60-0.90	7.00-10.00	19.00-23.00	Cu 1.00-1.50
30347	347	0.08 max.	2.50	17.00-19.00	9.00-13.00	Min. Cb = 10 x C
WROUGHT STAINLESS CHROMIUM IRONS AND STEELS††						
51410	410	0.15 max.	1.00	11.50-13.50	....	....
51414	414	0.08-0.15	1.00	11.50-13.50	1.25-2.50	....
51416F	416	0.15 max.	1.25	12.00-14.00	....	P, S, Se, Min. 0.07; Zr, Mo, Max. 0.60
51420	420	0.30-0.40	1.00	12.00-14.00	....	....
51420F	......	0.30-0.40	1.25	12.00-14.00	....	P, S, Se, Min. 0.07; Zr, Mo, Max. 0.60
51430	430	0.12 max.	1.00	14.00-18.00	....	....
51430F	......	0.12 max.	1.25	14.00-18.00	....	P, S, Se, Min. 0.07; Zr, Mo, Max. 0.60
51431	431	0.20 max.	1.00	15.00-17.00	1.25-2.50	....
51440A	440A	0.60-0.75	1.00	16.00-18.00	....	Max. Mo 0.75
51440B	440B	0.75-0.95	1.00	16.00-18.00	....	Max. Mo 0.75
51440C	440C	0.95-1.20	1.00	16.00-18.00	....	Max. Mo 0.75
51440F	......	0.95-1.20	1.25	16.00-18.00	....	P, S, Se, Min. 0.07; Zr, Mo, Max. 0.75
51442	442	0.20 max.	1.00	18.00-23.00	....	....
51446	446	0.25 max.	1.00	23.00-27.00	1.00 max.	....
51501	501	Over 0.10	1.00	4.00-6.00	....	....

* American Iron and Steel Institute.

** Maximum sulphur and phosphorus contents 0.040 percent each and silicon content 0.20-0.35 percent.

† The letters A, B, and C indicate three types of steel differing only in carbon content. The letter F indicates a free machining steel.

†† Maximum phosphorus content is 0.04 percent and maximum sulphur content is 0.03 percent except for SAE 51442 which has 0.035 percent sulphur, max.; SAE 30303F, 51416F, 51420F, 51430F, and 51440F, for which see Other Elements column; and SAE 30325, not specified. Maximum silicon content is 1.00 percent except for SAE 30310, 30321, and 30347 which have 1.50 percent, and SAE 30325 which has 1.00-2.00 percent.

ASSIGNMENT SHEET #2

CUTTING SPEEDS IN F.P.M. USING HIGH-SPEED STEEL TOOLS

Material	Turning, Boring, Facing		Milling	Threading	Drilling	Reaming	Knurling
SAE Number	Rough Cut	Finish Cut					
Aluminum	200	300	300-500	50	200	50	40
Brass	180	220	70-175	45	90	20	40
Bronze	90-180	120-220	50-130	45-60	50-70	20	40
Steel 1020	70	120	70	45	100	30	30
Steel 1095	70	100	60	40	70	20	30
Steel 1120	100	120	60	40	100	40	30
Steel 12L14	120	180	90	60	150	60	40
Steel 1330	60	70	70	30	90	30	30
Steel 2340	60	70	60	25	70	20	30
Steel 3145	60	70	50	30	90	30	30
Steel 4140	60	70	50	30	90	30	30
Steel 5120	70	85	70	25	70	20	30
Steel 6150	70	85	50	25	70	20	30
Steel 9260	70	85	40	20	60	20	30
Steel 8640	70	85	40	20	50	15	30
Steel 9840	70	85	40	20	50	15	30
Steel 30303F	40-70	60-90	30	20	40	15	20
Steel 30316	40-70	60-90	30	20	40	15	20
Steel 51420F	75-90	100-130	40	25	60	20	20

(NOTE: The SAE numbers of all steels are not listed. However, steels in the same group have similar cutting speeds.)

MATERIALS AND CUTTING FLUIDS
UNIT VIII

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

A. Ferrous
B. Non-ferrous
C. Non-metallic
D. Non-ferrous
E. Non-ferrous
F. Non-metallic
G. Ferrous or non-ferrous
H. Non-metallic
I. Ferrous
J. Non-ferrous
K. Non-metallic
L. Ferrous
M. Non-ferrous
N. Ferrous
O. Non-ferrous

Assignment Sheet #2

Steel	Carbon Content	Cutting Speed (CS)
AISI 4140	0.38 to 0.43	70
SAE 5120	0.17 to 0.22	85
SAE 1020	0.18 to 0.23	120
AISI C 1095	0.90 to 1.03	100
AISI C 1120	0.18 to 0.23	120
SAE 3145	0.43 to 0.48	70

Steel	Carbon Content	Cutting Speed (CS)
SAE 4140	0.38 to 0.43	70
AISI 303	0.15 maximum	60-90
SAE 51420F	0.30 to 0.40	100-130

MATERIALS AND CUTTING FLUIDS
UNIT VIII

JOB SHEET #1--PERFORM FILE AND SPARK TEST

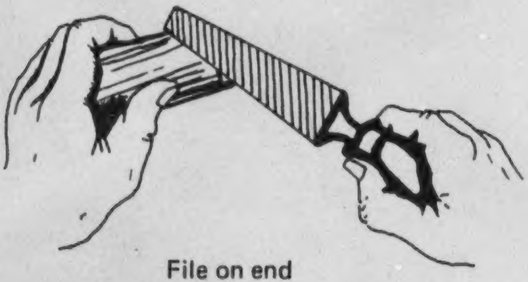
I. Tools and equipment

- A. Grinding wheel dresser
- B. Pedestal or bench grinder with coarse stone
- C. Goggles or face shield
- D. File
- E. Metal specimens (five different alloy materials that are marked with SAE numbers and three unmarked specimens marked 1, 2, and 3)

II. Procedure

- A. Take the file and file on the end of specimen 1; note whether the file cuts the material easily or with difficulty (Figure 1)

FIGURE 1



File on end

- B. File on each of the five SAE numbered specimens until you find one that cuts like specimen #1 and record

  Specimen number 1 = SAE ____________________

- C. Repeat steps A and B for specimens #2 and #3 and record

  Specimen number 2 = SAE ____________________

  Specimen number 3 = SAE ____________________

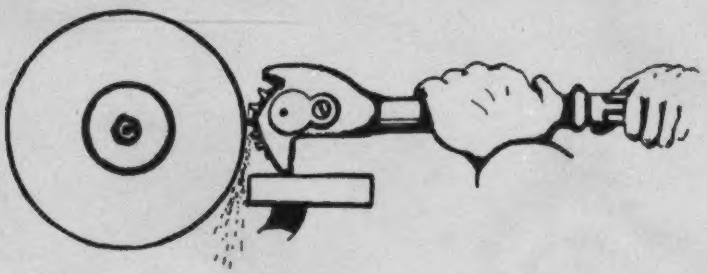
- D. Put on goggles or face shield

JOB SHEET #1

E. Dress the face of the grinding wheel (coarse stone) (Figure 2)

FIGURE 2

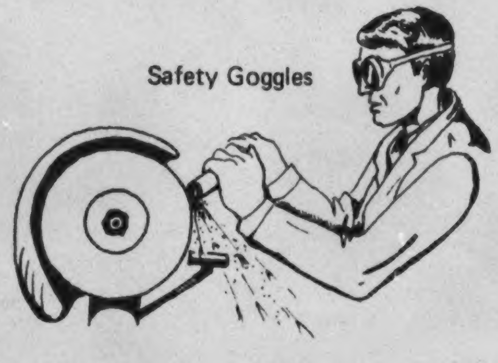
DRESSING WHEEL



F. Hold specimen #1 high on the face of the stone and apply a light pressure to observe sparks (Figure 3)

FIGURE 3

SPARK TEST



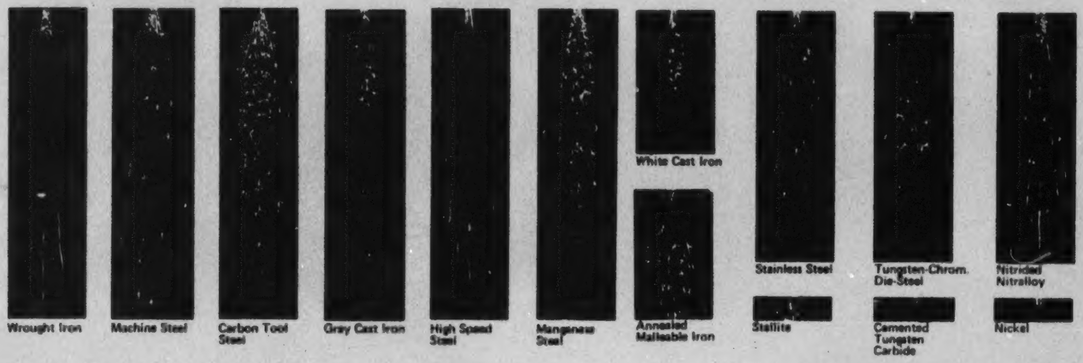
G. Observe spark pattern from specimen, and then compare that spark to the specimen you matched it with by the file test (See Figure 4 Spark Chart)

H. If they are not the same, grind on the other specimens to find one which matches and record

JOB SHEET #1

I. Use the spark chart and the SAE/AISI numbering systems to see the other alloy agents of the steel (Figure 4)

FIGURE 4


Wrought Iron
Machine Steel
Carbon Tool Steel
Gray Cast Iron
High Speed Steel
Manganese Steel
White Cast Iron
Annealed Malleable Iron
Stainless Steel
Stellite
Tungsten-Chrom. Die-Steel
Cemented Tungsten Carbide
Nitrided Nitralloy
Nickel

Characteristics of Sparks Generated by Grinding Metals

Metal	Volume of Stream	Relative Length of Stream, mm(in.)†	Color of Stream Close to Wheel	Color of Streaks Near End of Stream	Quantity of Spurts	Nature of Spurts
1. Wrought iron	Large	1651 (65)	Straw	White	Very few	Forked
2. Machine steel (AISI 1020)	Large	1778 (70)	White	White	Few	Forked
3. Carbon tool steel	Moderately large	1397 (55)	White	White	Very many	Fine, repeating
4. Gray cast iron	Small	635 (25)	Red	Straw	Many	Fine, repeating
5. White cast iron	Very small	508 (20)	Red	Straw	Few	Fine, repeating
6. Annealed malleable iron	Moderate	762 (30)	Red	Straw	Many	Fine, repeating
7. High-speed steel (18-4-1)	Small	1524 (60)	Red	Straw	Extremely few	Forked
8. Austenitic manganese steel	Moderately large	1143 (45)	White	White	Many	Fine, repeating
9. Stainless steel (Type 410)	Moderate	1270 (50)	Straw	White	Moderate	Forked
10. Tungsten-chromium die steel	Small	889 (35)	Red	Straw*	Many	Fine repeating*
11. Nitrided Nitralloy	Large (curved)	1397 (55)	White	White	Moderate	Forked
12. Stellite	Very Small	254 (10)	Orange	Orange	None	
13. Cemented tungsten-carbide	Extremely small	51 (2)	Light Orange	Light Orange	None	
14. Nickel	Very small**	254 (10)	Orange	Orange	None	
15. Copper, brass, aluminum	None				None	

†Figures obtained with 305 mm (12") wheel on bench stand are relative only. Actual length in each instance will vary with grinding wheel, pressure, etc

*Blue-white spurts.

**Some wavy streaks.

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MATERIALS AND CUTTING FLUIDS
UNIT VIII

TEST

NAME____________________________________ SCORE ____________

1. Match terms associated with materials and cutting fluids to the correct definitions. Write the correct numbers in the blanks provided.

_____a. Metal with iron as its major element; usually magnetic

_____b. Professional group that sets many manufacturing standards

_____c. Number of feet of material passing the cutting edge per minute

_____d. Metal that does not contain iron; not magnetic

_____e. Gives maximum tool life between grindings, with maximum chip or material removal

_____f. Angles ground on or angles of cutting tools

_____g. Having a decayed or rotten smell due to bacterial buildup; caused by contamination

_____h. Professional group that sets standards for steel

_____i. A metal material (ferrous or non-ferrous)

_____j. A material without metal

1. Tool bit geometry
2. Cutting speed
3. Ferrous
4. Sour
5. Metallic
6. SAE (Society of Automotive Engineers)
7. Non-ferrous
8. Allowable cutting speed
9. Non-metallic
10. AISI (American Iron and Steel Institute)

2. Distinguish between ferrous, non-ferrous, and non-metallic materials. Write an "F" for ferrous, an "N" for non-ferrous, and "N-M" for non-metallic in the blanks provided. Some blanks may have more than one correct answer.

_____a. Brass

_____b. Copper

_____c. Rubber

_____d. Tool steel

______e. Aluminum

______f. Plastic

______g. Mild steel

______h. Cast iron

______i. Bronze

______j. Ceramic

______k. Stainless steel

______l. High carbon steel

______m. Lead

______n. Glass

______o. Alloy steel

______p. Cast aluminum

3. State how different materials affect tool geometry. ____________________

____

____

4. Identify carbon content of steels from the SAE/AISI numbering systems. Write your answers in the spaces provided.

   a. SAE-4340 ________________

   b. SAE-1095 ________________

   c. SAE-30316 ________________

   d. AISI-C 1140 ________________

   e. AISI-C 1020 ________________

   f. AISI-E 2512 ________________

5. Describe factors that affect cutting speeds and tool bit geometry in the spaces below.

   a. Machinability of material-- ____________________________

   ____

   b. Hardness of material-- ______________________________

   ____

c. Toughness of material-- ______________________________

____

6. Match methods for testing for hardness and carbon content of steels to their definitions. Write the correct numbers in the blanks provided.

_____a. Test for hardness of materials; uses a carbide ball (B scale) or a cone-shaped diamond penetrator (C scale); measures depth of penetration and converts this to a standard scale; primarily used for inspection, but can be used to check for machinability

_____b. Test where metal displays a particular spark pattern when held against a grinding wheel; sparks are compared with known sample

_____c. Uses a ball penetrator to create impression on metal; diameter of impression is measured and converted mathematically

_____d. Test where metal is filed and ease or difficulty is noted

1. Spark test
2. File test
3. Rockwell test
4. Brinell test

7. Match kinds of cutting fluids to their uses. Write the correct numbers in the blanks provided.

_____a. Used when tapping or drilling by hand

_____b. Mix with water; used when cooling work and tool with light lubricating action; wash chips from work

_____c. Used where cooling work and when there is high chip-bearing pressure, as in machining alloy or other tough steels

_____d. Used to cool work and tool, improve finish, wash chips from work; contain no oil

1. Light and dark cutting oils
2. Emulsifying or soluble oils
3. Chemical emulsions
4. Chemical cutting fluids

8. Describe advantages of using cutting fluids in the spaces below.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

9. Describe reasons for using chemical cutting fluids in the spaces below.

   a. ______________________________

   b. ______________________________

   c. ______________________________

   d. ______________________________

   e. ______________________________

10. Demonstrate the ability to perform file and spark test.

    (NOTE: If this activity has not been finished before the test, ask your instructor when it should be completed.)

MATERIALS AND CUTTING FLUIDS
UNIT VIII

ANSWERS TO TEST

(NOTE: The point system designated in parentheses is intended to be a guideline and should be adapted as needed. The point total is 300.)

1. (20 points)

   a. 3
   b. 6
   c. 2
   d. 7
   e. 8
   f. 1
   g. 4
   h. 10
   i. 5
   j. 9

2. (48 points)

   a. N
   b. N
   c. N-M
   d. F
   e. N
   f. N-M
   g. F
   h. F
   i. N
   j. N-M
   k. N or F
   l. F
   m. N
   n. N-M
   o. F
   p. N

3. (3 points)

   As a general rule, the softer the metal, the more side clearance and side rake must be ground on the tool so it has a shearing action

4. (12 points)

   a. .40%/1%
   b. .95%/1%
   c. .16%/1%
   d. .40%/1%
   e. .20%/1%
   f. .12%/1%

5. (18 points)

   a. Machinability of material--How hard or easy a material is to cut
   b. Hardness of material--Resistance to penetration
   c. Toughness of material--Resistance to cutting

6. (8 points)

   a. 3 c. 4

   b. 1 d. 2

7. (8 points)

   a. 4

   b. 2

   c. 1

   d. 3

8. (48 points)

   a. Take the heat away from the part

   b. Prolong the life of the cutting edge of the tool

   c. Help in chip control by washing chips away from cutter

   d. Help in obtaining desired finish on part

   e. Help in machining parts to size by keeping part cool

   f. Help lubricate machine parts

9. (35 points)

   a. Will not sour as fast as soluble oils due to lack of bacteria-forming agents

   b. Are anti-allergenic

   c. Are easy to clean

   d. Do not stain machine

   e. Are not irritating to nose and throat

10. (100 points)

    Performance skills evaluated to satisfaction of instructor

HAND TOOLS
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify and use basic hand tools, and state safety rules that should be observed when using hand tools. This knowledge will be shown by completion of assignment sheets, job sheets, and unit test with a minimum score of 85 percent.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to

1. Match terms associated with hand tools to the correct definitions.
2. Label non-cutting hand tools with their appropriate name and use.
3. Label cutting hand tools with their appropriate name and use.
4. State rules for safe use of hand tools.
5. State rules for care of hand tools.
6. Describe reasons for tap failure.
7. Determine tap drill size.
8. Complete hand tool safety test.
9. Plan procedures for completing shop projects.
10. Demonstrate the ability to
    a. Use a hand hacksaw.
    b. Use file to square a part to size.
    c. Perform layout with combination square set.
    d. Hacksaw to layout.
    e. File to layout.
    f. Produce internal threads by hand tapping.
    g. Produce external threads with hand die.
    h. Assemble C-clamp.

HAND TOOLS
UNIT I

SUGGESTED ACTIVITIES

I. Suggested activities for instructor

   A. Provide students with objective and job sheets.

   B. Provide students with information and assignment sheets.

   C. Discuss unit and specific objectives.

   D. Discuss information and assignment sheets.

   E. Demonstrate and discuss procedures outlined in job sheets.

   F. Display the different cutting and non-cutting hand tools.

   G. Demonstrate the safe use of hand tools.

   H. Have advanced students machine a screw and swivel.

   (NOTE: Blueprints for these parts are given in the blueprint page included with Job Sheet #1.)

   I. Have advanced students set up and drill all holes to blueprint specifications after Job Sheet #3 has been completed.

   J. Have students make parts shown in Assignment Sheet #3 as supplemental projects.

   K. Give test.

   L. Reteach and retest if necessary.

II. Instructional materials

   A. Objective sheet

   B. Information sheet

   C. Assignment sheets

      1. Assignment Sheet #1--Complete Hand Tool Safety Test

      2. Assignment Sheet #2--Determine Tap Drill Size

      3. Assignment Sheet #3--Plan Procedures for Completing Shop Projects

   D. Answers to assignment sheets

E. Job sheets

1. Job Sheet #1--Use a Hand Hacksaw
2. Job Sheet #2--Use File to Square a Part to Size
3. Job Sheet #3--Perform Layout with Combination Square Set
4. Job Sheet #4--Hacksaw to Layout
5. Job Sheet #5--File to Layout
6. Job Sheet #6--Produce Internal Threads by Hand Tapping
7. Job Sheet #7--Produce External Threads with Hand Die
8. Job Sheet #8--Assemble C-Clamp

F. Test

G. Answers to test

III. Unit references

A. *Starrett Tool Catalog #28.* Athol, MA: The L. S. Starrett Company, 1979.

B. Brown & Sharpe Catalog #STM80. *The Shop Tool Manual.* North Kingston, RI: Brown & Sharpe Manufacturing Company, 1980.

C. Kibbe, Richard R.; Neely, John E.; Meyer, Roland O.; and White, Warren T. *Machine Tool Practices.* New York: John Wiley and Sons, 1979.

D. McCarthy, Willard J., and Smith, Robert E. *Machine Tool Technology.* Bloomington, IL: McKnight and McKnight, 1968.

HAND TOOLS
UNIT I

INFORMATION SHEET

I. Terms and definitions

A. Chipping--Producing a chip by using a chisel

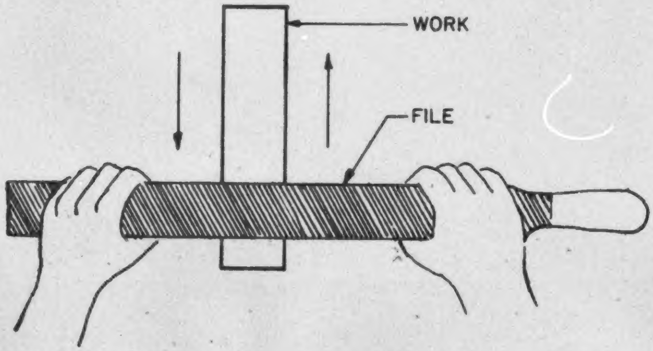
B. Mushroom--The enlarged area on the end of a chisel, caused by striking it with a hammer

C. Tang--The pointed end of a file

D. Shearing--The cutting action of a tool

E. Drawfiling--Pushing and pulling a file sideways along the work

Example:



F. Burr--The sharp edge left on a metal part from a machining operation

G. Hardening--Process of making metal resistant to wear

Example: A file is made of steel and hardened so it will stay sharp; hammer heads are hardened to keep them from being deformed when striking another object

H. Brittle--Easy to break

Example: A file is brittle because it is made of hardened steel

I. Personal injury--Harm to an individual

J. Reference surface--The side from which dimensions are taken or made

K. Tap drill size--The size a hole is drilled for a specific size tap

L. Threading die--Tool used to produce external threads

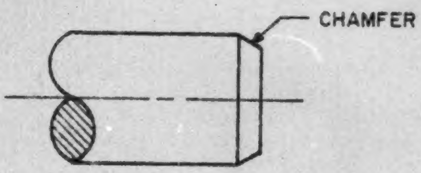
M. Layout solution--A thin colored lacquer that is painted or sprayed on the surface of a part so layout lines can be seen clearly

INFORMATION SHEET

N. Scale--A semi-precision steel rule with graduations

O. Chamfer--An angled surface

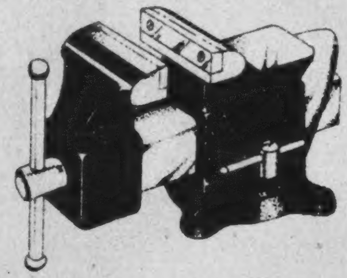
Example:



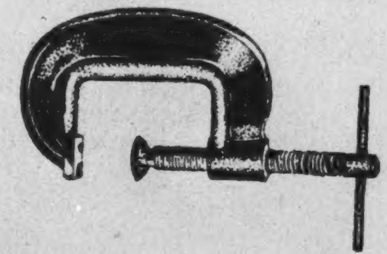
P. Tap--A cutting tool used to cut internal threads

II. Non-cutting hand tools and their uses

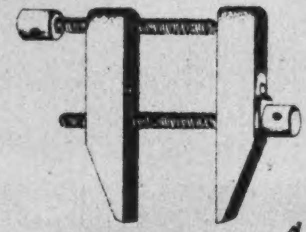
A. Machinist's bench vise--Used to hold parts for sawing, filing, or other hand operations



B. C-clamp--Used to hold one part to another by pressure of a screw and anvil

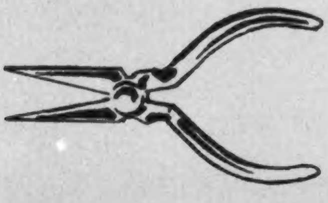


C. Parallel clamp--Used when holding two precision parts together with two parallel jaws

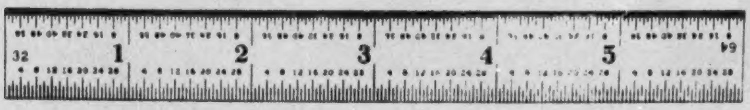


INFORMATION SHEET

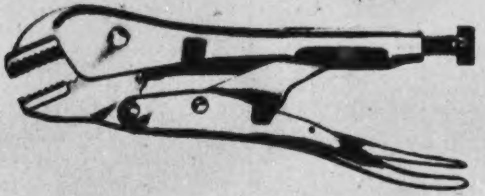
D. Long nose pliers–Used for placing or removing small items in narrow spaces, and when twisting and bending wire during electrical repairs



E. Steel rule (scale)--Used to measure lengths and to set semi-precision tools like dividers

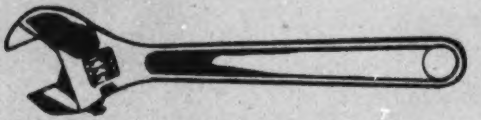


F. Locking pliers (vise-grips)--Used to lock on a part when turning; have a mechanical pressure and lock system



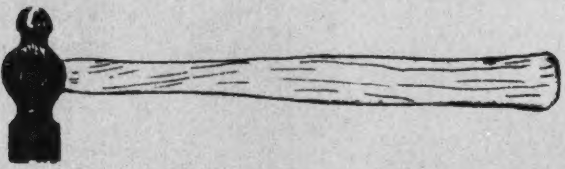
G. Adjustable wrench--Used to loosen or tighten bolts and nuts; one size fits many

(NOTE: Caution must be taken when using because it is easy to over-tighten a wrench, causing it to slip and damage the nut head or bolt, or injure the user.)



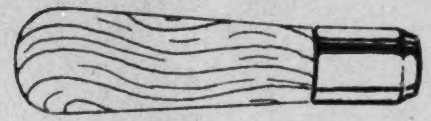
INFORMATION SHEET

H. Ball peen hammer--Used to drive a chisel or flair a pin



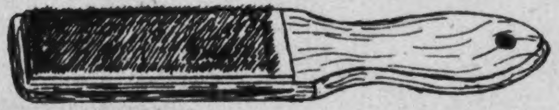
I. File handle--Used to cover the tang of a file

(NOTE: This makes the file safer to use as well as giving the user a convenient surface to hold when filing.)



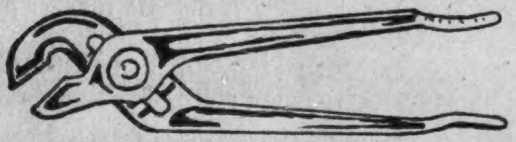
J. File card–Used to clean a file

(NOTE: Some file cards have short wire bristles on one side for cleaning hard imbedded particles from a file, and a brush on the other side to finish cleaning.)



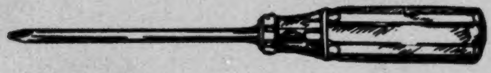
K. Tongue and groove pliers--Used to tighten or loosen couplings or fittings

(NOTE: Pliers should not be used in place of a wrench if at all possible.)

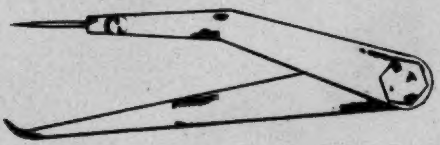


INFORMATION SHEET

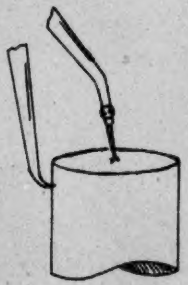
L. Phillips screwdriver--Used to tighten or loosen screws and bolts which have a head with four slots that slant downward



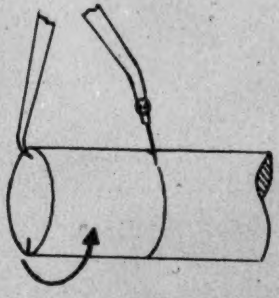
M. Firm joint hermaphrodite caliper–Used for layout from a reference surface; must be set with a scale



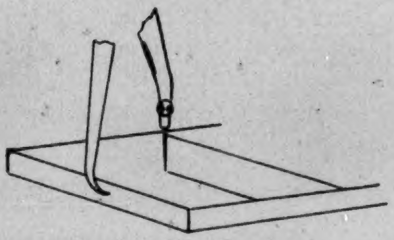
Examples of use:



Locating centers



Marking lines on round surface

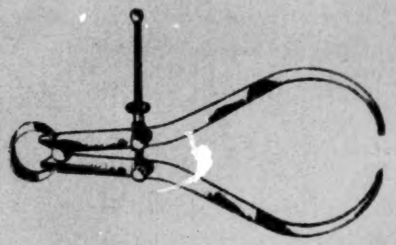


Locating lines

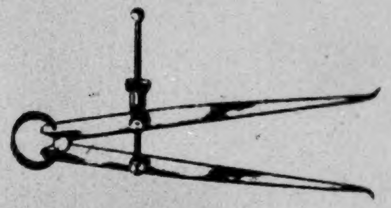
INFORMATION SHEET

N. Outside caliper–Used to measure outside diameters

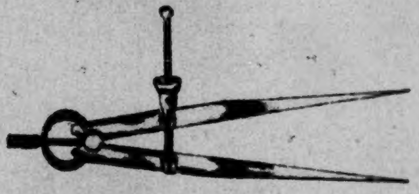
(NOTE: Measurements are transferred to a steel rule or other measuring tool for reading the size. Both inside and outside calipers may be pre-set to determine when a diameter is getting close to size.)



O. Inside caliper–Used to measure inside diameters and widths of slots



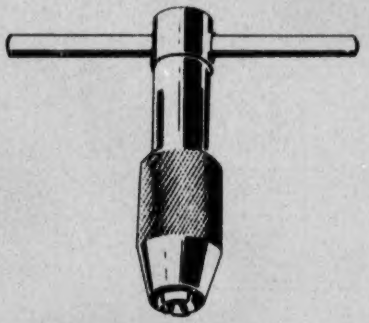
P. Divider–Used to lay out circles, arcs, measure distance between points, and to transfer a measurement directly from a steel rule



INFORMATION SHEET

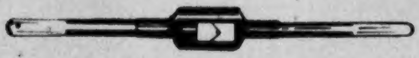
Q. Tap handle--Used to drive taps, hand reamers, and screw extractors

(NOTE: Tap handles are designed and made for different size taps and should be used with the correct size tap.)

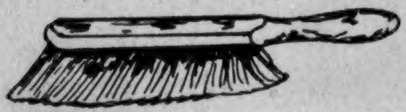


R. Tap wrench--Used to drive taps, hand reamers, and screw extractors of larger sizes (3/8" and up)

(NOTE: These tools are made for different ranges of taps and should be used with the correct size tap.)

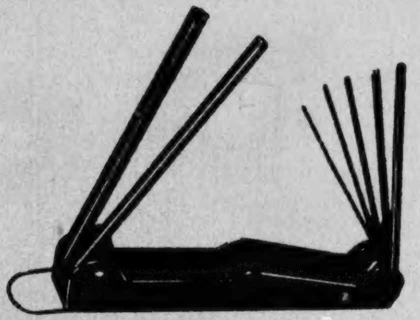


S. Counter or bench brush--Used when cleaning up bench or counter; has long fine bristles that will clean fine chips from work area

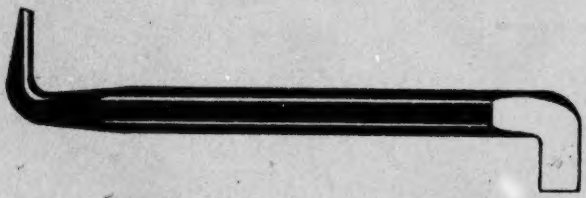


INFORMATION SHEET

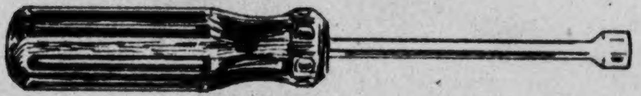
T. Hex key set--Used to tighten or loosen socket head screws



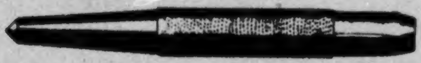
U. Offset screwdriver--Used to tighten or loosen screws in places where height is limited



V. Nut driver--Used to tighten or loosen small machine screws and nuts with hexagonal heads; the socket on the end is made to fit a particular size

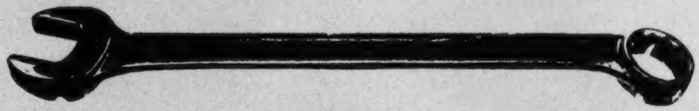


W. Center punch--Used to mark the location of a hole prior to drilling by making a dent in the surface of the material

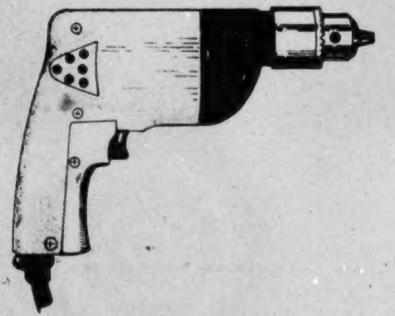


INFORMATION SHEET

X. Combination (open and box end) wrench--Used to tighten or loosen square and hexagon head bolts of a particular size; prevents slippage

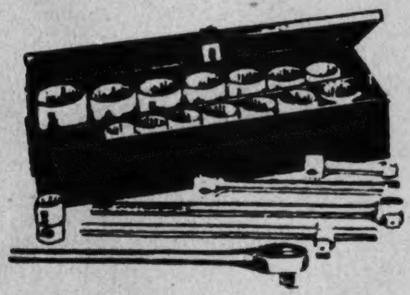


Y. Electric hand drill motor (hand-held)--Used to drill or ream holes and is semi-portable



Z. Socket wrench set--Used to tighten or loosen bolts and nuts with hexagonal heads, usually in places where space is limited

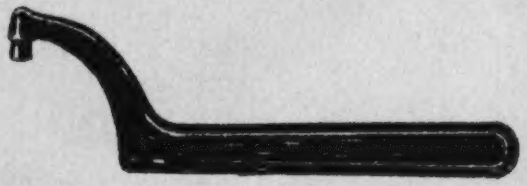
(NOTE: The wrench or socket wrench handle has a ratchet that permits movement without removing the socket from the bolt. This is useful when performing machine maintenance.)



INFORMATION SHEET

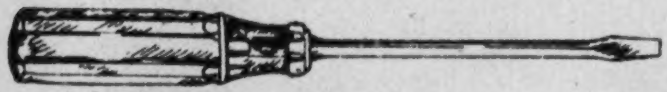
AA. Pin spanner wrench--Used to tighten or loosen nuts than have holes instead of flats that fit the pin

(NOTE: A hook wrench looks similar to a pin spanner wrench, but has a square and is made to fit in slotted nuts and bolt heads.)

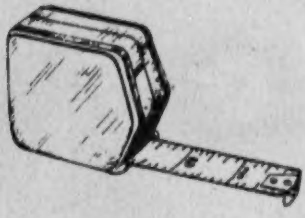


BB. Standard screwdriver--Used to tighten or loosen a screw that has a slotted head

(NOTE: Screwdrivers are made in many sizes and it is important to select the size that fits the screw head.)

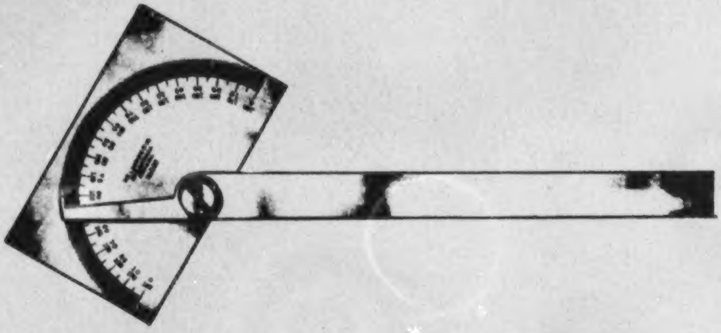


CC. Steel tape rule (tape measure)--Used to measure long dimensions or contoured surfaces to 1/32" accuracy



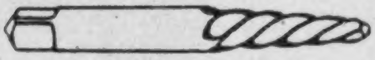
INFORMATION SHEET

DD. Protractor--Used to lay out or measure angles to an accuracy of one degree

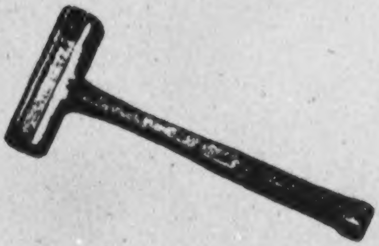


Used with permission of L.S. Starrett Company

EE. Screw extractor ("easy-out")--Used to remove bolts and screws whose heads have been broken off or damaged



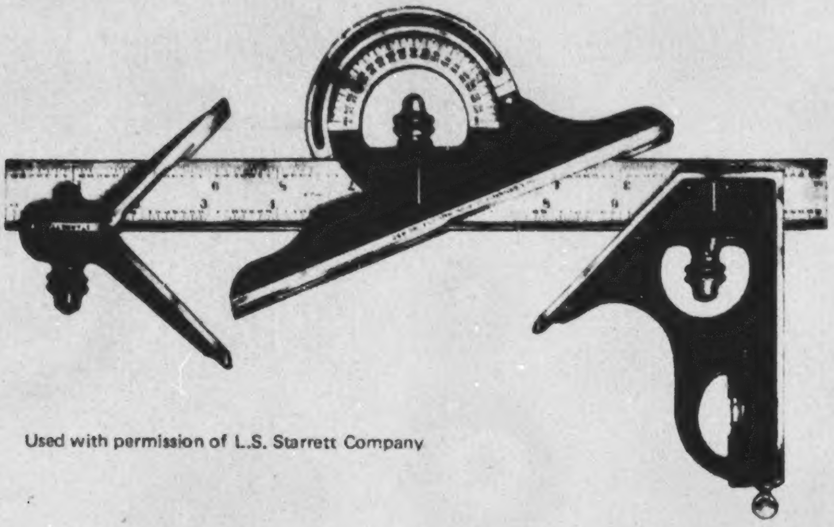
FF. Soft face mallet--Used for moving objects by tapping; made of rubber, plastic, or rawhide so it does not damage the part or attachment being struck



INFORMATION SHEET

GG. Combination square set--Used to lay out straight and angular dimensions, measure and check angles, check for squareness, and locate center of round parts

(NOTE: Each of the parts are used separately with the steel blade.)



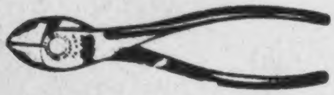
Used with permission of L.S. Starrett Company

HH. Die stock–Used to hold round threading dies when cutting threads by hand

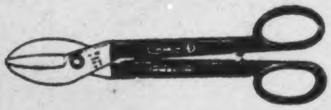
INFORMATION SHEET

III. Cutting hand tools

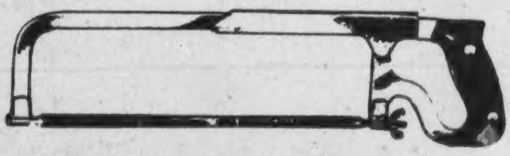
A. Side cutters--Used to cut soft wire or steel bands



B. Tin snips--Used to cut thin sheet metal, shim stock, or band saw blade material to size or shape

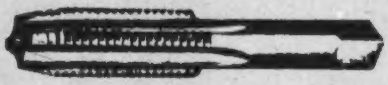


C. Hand hacksaw--Used to saw metal parts to size or shape by hand



D. Tap--Used to produce internal threads in a hole that has been drilled to a specific size

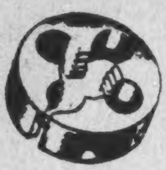
(NOTE: Taps have different shaped points and numbers of flutes depending on the application, taper, plug, and bottoming.)



INFORMATION SHEET

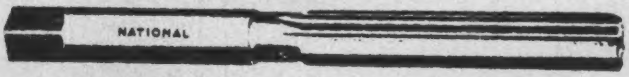
E. Adjustable threading die--Used to produce external threads on stock of a particular size by hand; mounted in a die stock which holds and turns threading die

(NOTE: One side of this die has a taper, which is placed on the part to be threaded.)



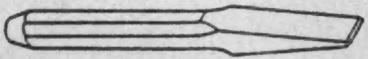
F. Hand reamer--Used when it is necessary to produce a hole that is accurate and smooth; designed to remove only .002" to .005" of material

(NOTE: Hand reamers are not to be used by any other power than hand. Other methods of reaming will be discussed in later units.)



G. Cold chisel--Used for chipping flat surfaces and for cutting thin sheet metal

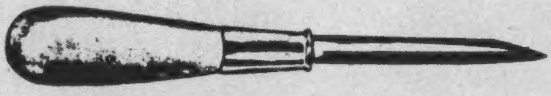
(NOTE: Other shapes of chisels are cape, roundnose, and diamond-point; these are used to cut grooves, keyways and small slots.)



INFORMATION SHEET

H. Machinist's scraper (burr knife)--Used to remove burrs from holes, slots, grooves or edges of machined parts by hand

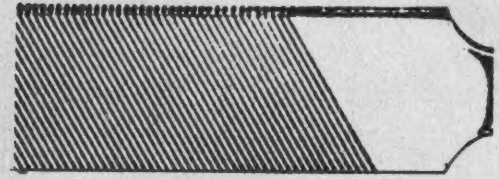
(NOTE: This tool has three sharp edges and can be made by skillful hands using a pedestal grinder and a worn-out 3-edge file.)



I. File--Used to shape a part to size or remove sharp edges from a part

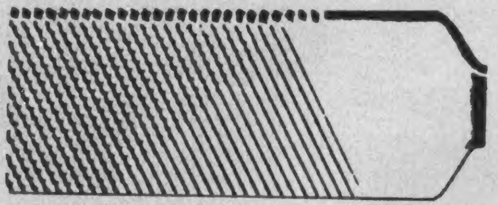
1. Single-cut (mill file)--Used for drawfiling, lathe work, and general purpose filing where a smooth finish is required

   (NOTE: Single-cut mill files have bastard, smooth and dead smooth cut of teeth.)



2. Double-cut (machinist's file)--Used whenever material must be removed rapidly

   (NOTE: Files came in various shapes and lengths.)



INFORMATION SHEET

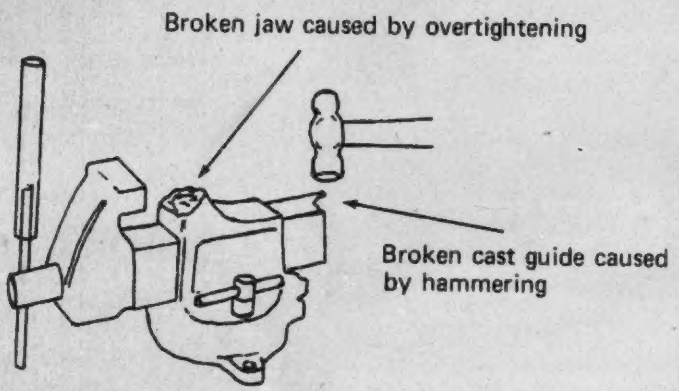
IV. Rules for safe use of hand tools (Assignment Sheet #1)

(NOTE: *Safe use* implies safety to the user from being injured and safety to the tools from being damaged by the user.)

A. Machinist's bench vise

1. Always clamp work well in the jaws
2. Do not use a cheater bar or hammer to tighten vise
3. Never hammer on vise guides; the casting will not stand the force

   Example:


Broken jaw caused by overtightening
Broken cast guide caused by hammering

B. Wrenches

1. Use wrench of correct size
2. Adjustable wrenches should be used *only* as a last resort because they can slip, damaging the nut and possibly injuring the user
3. It is safer to pull a wrench toward you than to push it away from you

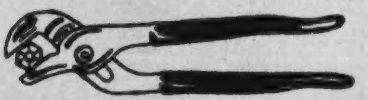
INFORMATION SHEET

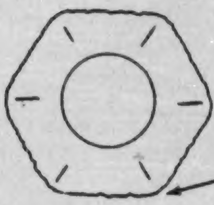
C. Pliers

1. Do not use pliers to loosen or tighten a bolt or nut; they will damage the head

2. Never use pliers to grip finished surfaces because the teeth will score the work

   Example:



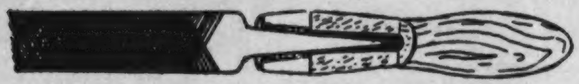


Corners rounded
or sharp edges
produced with
serrated edge
of pliers

3. If you must use pliers on a bolt or nut, use locking pliers that will not slip as easily

D. Files

1. Never use a file that is not equipped with a handle to prevent possible stab wounds from the spear-like point (tang)



2. Never use a file as a pry bar; it will break and can cause injury

3. When filing, apply pressure on forward stroke only

E. Screwdrivers

1. Never use a screwdriver as a chisel because it will damage the screwdriver

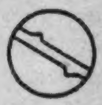
2. Never hold work while using a screwdriver; lay it on a bench or hold it in a vise, if the screwdriver slips it can cause a stab wound

INFORMATION SHEET

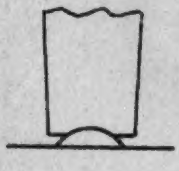
3. Always use a screwdriver that fits the head of the screw or you will damage the screw or screwdriver

   Examples:

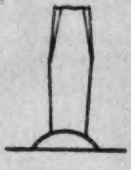
DAMAGED HEAD



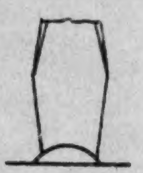
TOO BIG



TOO SMALL



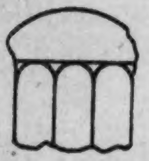
GOOD

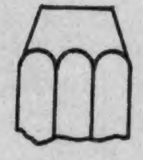


F. Chisels

1. Never use a chisel with a mushroomed head as it can chip off and cause injury; grind the head smooth

   Example:





2. When using a chisel for chipping, always chip away from yourself and others

G. Cleaning chips from work

1. Use a brush to clean chips from machine or work
2. Never use air hose with high pressure to clean machine or work; chips can be blown into machinery or someone's eyes

H. Hand hacksaws

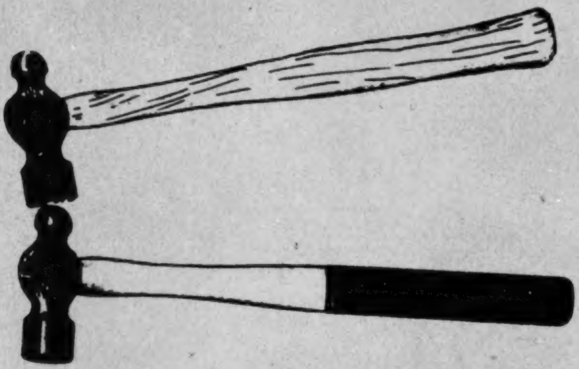
1. Hold part in vise close to the vise jaws
2. Ease up on the pressure when you are about to cut through the work so your hands will not strike work or vise
3. Apply pressure only on forward stroke using the entire length of the blade
4. Saw about 40 strokes per minute and do not bend the blade

INFORMATION SHEET

I. Hammers

1. Never use a hammer that has a split handle or loose head
2. Never use a hammer on precision parts
3. Never strike two hard surfaces together; a piece may break off one of them and hurt someone or damage the parts

   Example:



J. General

1. Report all damaged equipment to instructor
2. Report all injuries to instructor
3. Always store sharp pointed tools in a place where you will not stab yourself with them

V. Care of hand tools

A. Always use tool to do work for which it was designed

B. Wipe chips and grease from tools before storing

C. Always store tools in proper place

D. Protect tools from rust; oil after using

E. Inspect tools to make sure they are in good working condition

F. Never use cheater bar on wrenches to get more leverage

INFORMATION SHEET

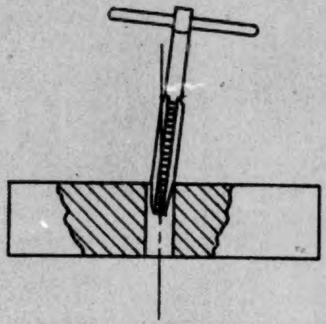
VI. Reasons for tap failure

(NOTE: Taps come in a variety of shapes and flutes, making correct tap selection very important.)

A. A hole that has been drilled too small requires more pressure than the tap can stand

B. A tap that is not straight with the hole will bind

Example:



C. A dull tap requires excessive pressure

D. Not using cutting fluid when required will cause a tap to bind

E. Failure to back up and break the chip puts too much pressure on the top

F. Failure to reverse direction of the tap once the point has reached the bottom of the hole will leave chip buildup

G. Using a too-large tap wrench will not let you feel how much torque you are applying

VII. Determining tap drill size (Assignment Sheet #2)

(NOTE: The size of the tap drill will vary with the size of the tap and the number of threads per inch.)

A. Use a tap drill chart

1. Locate the size of tap on chart

2. Determine number of threads per inch of tap

Example:
7/16 - 20NF tap
7/16 = size
20 = Number of threads per inch

INFORMATION SHEET

3. Move down column marked "tap drill" to size and threads of tap; that intersection is the tap drill for the particular size of tap

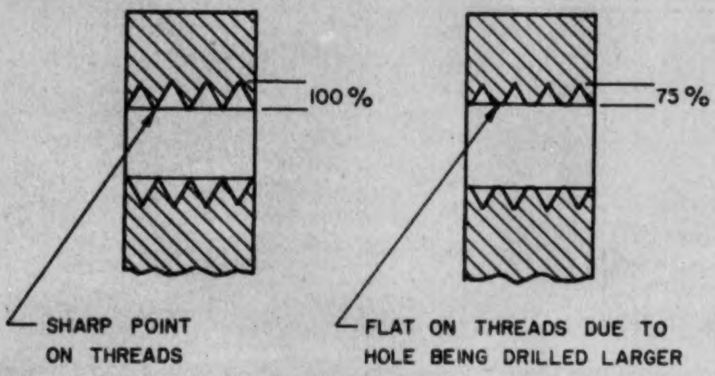
Example: (only a portion of a chart)

size		tap drill
7/16 - 20NF	=	25/64 (.390)
5/8 - 11NC	=	17/32 (.531)

Tap	Tap Drill	Decimal Equiv. of Tap Drill	Probable Hole Size	Percent of Thread
7/16-14	T	.3580	.3626	81
	23/64	.3594	.3640	79
	U	.3680	.3726	70
	3/8	.3750	.3796	62
	V	.3770	.3816	60
7/16-20	W	.3860	.3906	72
	25/64	.3906	.3952	65
	X	.3970	.4016	55
1/2 -13	27/64	.4219	.4266	73
	7/16	.4375	.4422	58
1/2 -20	29/64	.4531	.4578	65
9/16-12	15/32	.4688	.4736	82
	31/64	.4844	.4892	68
9/16-18	1/2	.5000	.5048	80
	33/64	.5156	.5204	58
5/8 -11	17/32	.5313	.5362	75
	35/64	.5469	.5518	62
5/8 -18	9/16	.5625	.5674	80
	37/64	.5781	.5831	58

(NOTE: There are two other columns: one marked "Probable Hole Size" which has the probable amount oversize the hole will be drilled, and one marked "Percent of Threads" which is the working distance of the thread, and is usually never more than 75 percent.)

Example:



INFORMATION SHEET

B. Use shop formula to calculate standard

1. Write the size (diameter) of the tap as a decimal

   Example: 7/16 = Diameter of tap; 7/16 = .4375

   (NOTE: Machine screw taps are listed by number from 0 to 14. When it is necessary to calculate the diameter of a tap, multiply the number of the tap by .013 and add .060, which equals the diameter of the tap.)

   Example: Tap is #6-32; 6 x .013 = .078 plus .060 = .138 = diameter of tap

   Divide the number of threads per inch of the tap into 1

   Example: 7/16 - 20NF

   $$20\,\overline{)\,1.000}^{\;.050}$$

3. Subtract the answer from the diameter of the tap

   Example: 7/16 - 20NF

   $$\text{Tap Drill Size} = \text{Size} - \frac{1}{\text{Number of threads}}$$

   7/16 = .4375 - .050 = .3875, which is about 75 percent of thread

   (NOTE: Use the closest drill size to the calculated decimal.)

C. Use shop formula to calculate a particular percentage of thread

1. Multiply the percentage of thread desired by .01299 and divide by the number of threads the tap is to produce

2. Subtract the answer from the size of the tap, giving you the tap drill size

   Example: 7/16 - 20NF for 60% thread

   $$\text{T.D.S.} = .4375 - \frac{(.01299 \times 60)}{20} =$$

   .4375 - .03897 = .3986

   T.D.S. = .3986

HAND TOOLS
UNIT I

ASSIGNMENT SHEET #1–COMPLETE HAND TOOL SAFETY TEST

NAME ______________________________ SCORE ______________

(NOTE: This test must have a score of 100 percent accuracy.)

Safety is everyone's responsibility. You must learn how to work safely to keep from being injured. You must also learn how to use tools properly so they do not get damaged by your misuse.

1. When using a machinist's bench vise, what three things should the user be aware of?

   a. ______________________________

   b. ______________________________

   c. ______________________________

2. Why is it better to use a wrench of the correct size than an adjustable wrench?

   ____

   ____

3. Is it safer to pull or push a wrench? ______________________________

4. Why should you never strike two hard objects like hammers together? ______________

   ____

5. Why should pliers never be used to tighten or loosen nuts or bolts? ______________

   ____

6. Why is the tang of a file protected with a file handle? ______________________

   ____

7. What causes the blade of a screwdriver to chip or the head of a screw to be damaged?

   ____

8. Why should files made of hardened steel never be used as pry bars? ______________

   ____

9. Damaged screwdrivers are caused by ______________________________

   ____

ASSIGNMENT SHEET #1

10. When using a screwdriver it is safer to lay the work on the bench or hold it in a vise rather than holding it in your hand because ____________________________

____

11. Always store sharp and pointed tools in a place where you will ______________

____

12. Never use a hammer that has a split handle or loose head because______________

____

13. What should you do to a chisel that has a mushroomed head to make it safer to use?

____

14. When chipping with a chisel, what should the user always do? ______________

____

15. Why is it safer to use a brush to remove chips from work instead of an air hose?

____

16. When using the hacksaw, always hold part in a vise close to jaw, and ease up on the___ __________when you are about to cut through so____________will not strike the vise or work

17. Reporting all accidents or damaged tools will help ____________________

____

HAND TOOLS
UNIT I

ASSIGNMENT SHEET #2–DETERMINE TAP DRILL SIZE

NAME ______________________________ SCORE ______________

When drilling a hole to be tapped, the hole must be drilled a particular size that is smaller than the nominal size of the tap, so that the tap will produce threads of the proper percentage in the work piece.

Use the chart provided and find the tap drill size (T.D.S.) for each of the following taps.

1.

	Drill Size	Decimal Equivalent
a. 1/4 - 28 NF		
b. 3/8 - 16 NC		
c. 1/2 - 20 NF		
d. 3/4 - 16 NC		
e. 7/8 - 9 NC		
f. #10 - 24 NC		
g. #6 - 40 NF		

(NOTE: Letters f. and g. are number taps.)

MACHINE SCREW SIZES UNC and UNF

NOMINAL SIZE TAP	RECOMMENDED TAP DRILL		PROBABLE HOLE SIZE	% THREAD
	DRILL	DEC.		
0-80	3/64	.0469	.0484	71
1-64 1-72	53 53	.0595 .0595	.0610 .0610	59 67
2-56 2-64	50 50	.0700 .0700	.0717 .0717	62 70
3-48 3-56	47 46	.0785 .0810	.0804 .0829	69 69
4-40 4-48	43 42	.0890 .0935	.0910 .0955	65 61
5-40 5-44	38 37	.1015 .1040	.1036 .1063	65 63
6-32 6-40	36 33	.1065 .1130	.1091 .1156	71 69
8-32 8-36	29 29	.1360 .1360	.1389 .1389	62 70
10-24 10-32	26 21	.1470 .1590	.1502 .1622	74 66
12-24 12-28	16 15	.1770 .1800	.1805 .1835	66 70

FRACTIONAL SIZES UNC and UNF

NOMINAL SIZE TAP	RECOMMENDED TAP DRILL		PROBABLE HOLE SIZE	% THREAD
	DRILL	DEC.		
1/4-20 1/4-28	7 3	.2010 .2130	.2048 .2168	70 72
5/16-18 5/16-24	F I	.2570 .2720	.2608 .2761	72 67
3/8-16 3/8-24	5/16 Q	.3125 .3320	.3169 .3364	72 71
7/16-14 7/16-20	U 25/64	.3680 .3906	.3726 .3952	70 65
1/2-13 1/2-20	27/64 29/64	.4219 .4531	.4266 .4578	73 65
9/16-12 9/16-18	31/64 33/64	.4844 .5156	.4892 .5204	66 58
5/8-11 5/8-18	17/32 37/64	.5312 .5781	.5361 .5631	75 58
3/4-10 3/4-16	21/32 11/16	.6562 .6875	.6612 .6925	68 71
7/8-9 7/8-14	49/64 13/16	.7656 .8125	.7708 .8177	72 62
1-8 1-12	7/8 59/64	.8750 .9219	.8809 .9279	73 67

2. Use the tap drill formula to calculate the tap drill for the following size of taps for a 65% thread. Leave answers in decimal form. Show all work.

Formula

$$\text{T.D.S} = \text{Nominal size of tap} - \frac{(.01299 \times \text{percent of thread desired})}{\text{Number of threads}}$$

ASSIGNMENT SHEET #2

a. 7/16 14NC = ________________ size of tap drill

b. 5/8 18NF = ________________ size of tap drill

c. 1 1/4 7NC = ________________ size of tap drill

3. Use the standard T.D.S. formula and calculate the tap drill size for the following taps. Show all work and leave answers in decimal form.

Formula

T.D.S. = size - $\frac{1}{N}$

a. 3/8 24NF = ________________ size of drill

b. 1/2 13NC = ________________ size of tap

HAND TOOLS
UNIT I

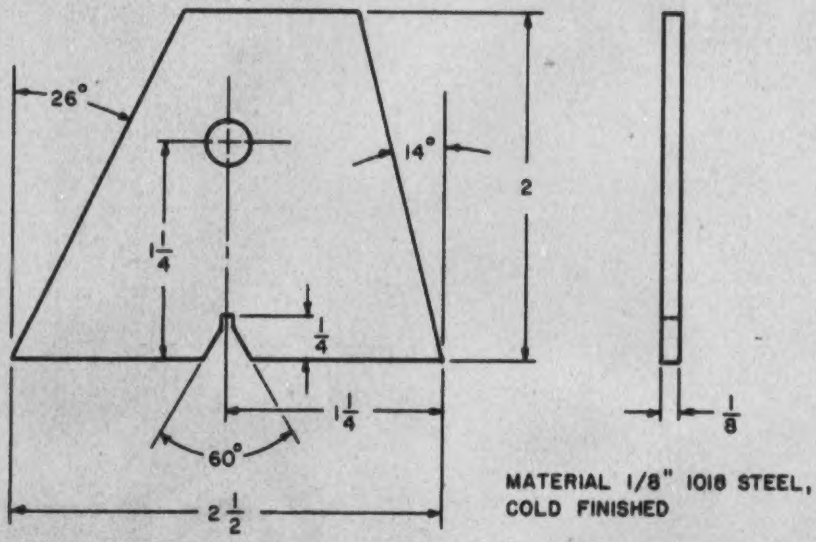
ASSIGNMENT SHEET #3--PLAN PROCEDURES FOR COMPLETING SHOP PROJECTS

NAME ______________________________ SCORE ______________

Knowing how to use the tools is only half the job; the other half is planning how you are going to perform the job. Developing the skills to plan and do the job shows real growth.

(NOTE: All job sheets should be completed before beginning this assignment sheet.)

PART 1–TOOL BIT GRINDING GAGE


26°
14°
2
1 1/4
1/4
1 1/4
60°
2 1/2
1/8
MATERIAL 1/8" 1018 STEEL,
COLD FINISHED

A. List the step-by-step procedure you would use to make this part.

ASSIGNMENT SHEET #3

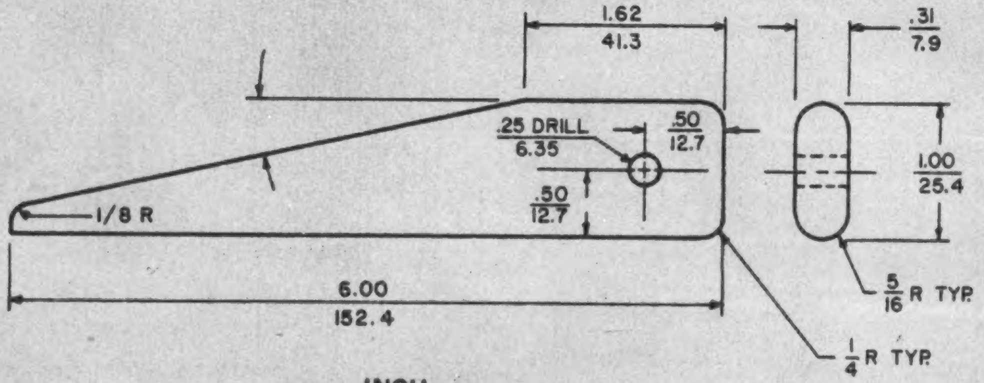
B. List the tools required to complete this job.

1. ______________________ 5. ______________________
2. ______________________ 6. ______________________
3. ______________________ 7. ______________________
4. ______________________ 8. ______________________

C. Estimate how long it will take to complete this part.

____

PART II--DRILL DRIFT


1.62
41.3
.31
7.9
.25 DRILL
6.35
.50
12.7
.50
12.7
1.00
25.4
1/8 R
6.00
152.4
5/16 R TYP.
1/4 R TYP.

NOTE: $\frac{\text{INCH}}{\text{MM}}$ Material 1095 Steel

<table>
<tr><th colspan="3">PROJECT NAME</th><th>DATE</th></tr>
<tr><td colspan="3">Drill Drift</td><td>7-12-77</td></tr>
<tr><td>DRAWN By J. Dunn</td><td colspan="3">CHECKED By J. D.</td></tr>
<tr><td>SHEET No. 1</td><td colspan="2">No. OF SHEETS 1</td><td>SCALE 1/1</td></tr>
<tr><td rowspan="2">TOLERANCE</td><td>Decs. xx= .010</td><td>.xxx = . 002</td><td>ANG = 30′</td></tr>
<tr><td>x.x = .20 m m</td><td colspan="2">x. x.xx = .06 m m</td></tr>
</table>

(NOTE: Heat treat and draw to a Rockwell of 55c)

ASSIGNMENT SHEET #3

A. List the step-by-step procedure you would use to make this part.

____

____

____

____

____

____

____

____

B. List the tools required to complete this job.

1. ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________
6. ____________________
7. ____________________
8. ____________________

C. Estimate how long it will take to complete this part.

____

HAND TOOLS
UNIT I

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

1. a. Always clamp work well in the jaws

   b. Do not use cheater bar or hammer to tighten vise

   c. Never hammer on vise guides; the casting will not stand the force

2. Adjustable wrenches can slip, causing damage to the bolt or nut or injury to the user

3. Pull

4. A piece may break off one of them, causing injury

5. They will damage the head, and can cause injury if they slip

6. To prevent stab wound to the user

7. A screwdriver that does not fit the screw

8. They will break very easily

9. Using the screwdriver as a chisel or striking it with a hard object (hammer)

10. If the screwdriver slips it can cause a stab wound

11. Not stab yourself with them

12. The head can break off and cause injury to someone

13. Grind off the mushroomed head

14. Chip away from self and others

15. The air can blow chips into someone's eyes

16. Pressure, your hands

17. Keep all tools in good working condition and keep someone from being injured by using a damaged tool

Assignment Sheet #2

1.	a.	#3	.2130
	b.	5/16	.3125
	c.	29/64	.4531
	d.	11/16	.6875
	e.	49/64	.7656
	f.	#26	.1470
	g.	#33	.1130

2. a. 3772

b. .5781

c. 1.12938

3. a. .3334

b. .4231

Assignment Sheet #3

Evaluated to satisfaction of instructor

HAND TOOLS
UNIT I

JOB SHEET #1--USE A HAND HACKSAW

I. Tools

A. 6 or 12" steel rule (scale) and scribe

B. Bench vise with soft jaws

C. Hand hacksaw

D. 3/4" diameter 1018 C.R.S. bar

E. 3/4" x 2" 1018 C.R.S. flat stock

F. 3/16" diameter 1018 C.R.S. bar

G. File with handle

H. Square

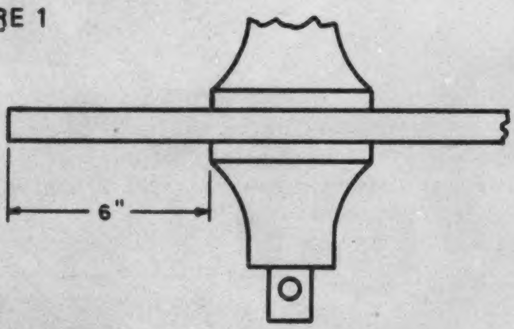
I. File card

J. Blueprint of C-clamp (included with this job sheet)

II. Procedure

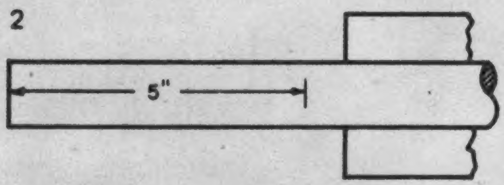
A. Clamp 3/4" bar in bench vise so that about 6" extends past edge of vise (Figure 1)

FIGURE 1



B. Use steel rule (scale) and mark a 5" length with scribe

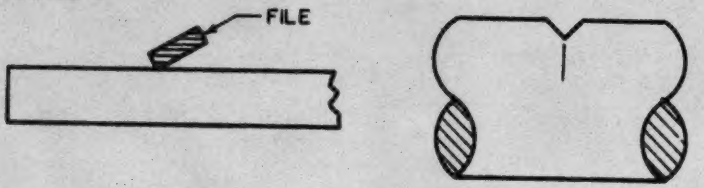
FIGURE 2



JOB SHEET #1

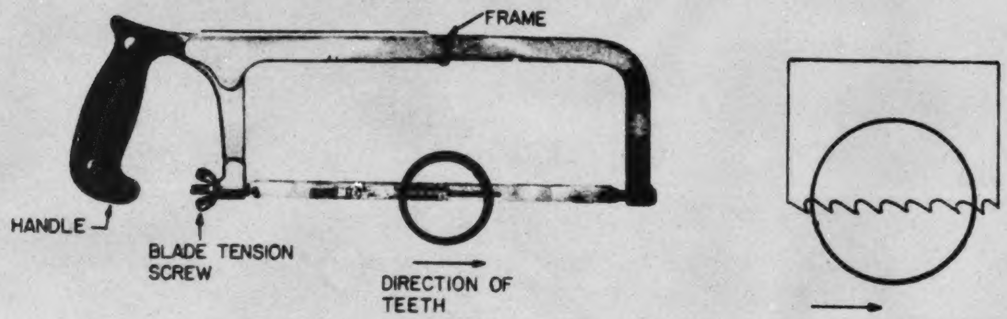
C. Use file to make a v-groove on 5" mark (Figure 3)

FIGURE 3



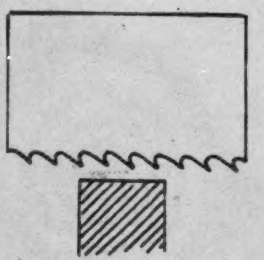
D. Check hand hacksaw to make sure the blade is tight, the teeth are sharp, and the teeth are going the right direction (Figure 4)

FIGURE 4


FRAME
HANDLE
BLADE TENSION SCREW
DIRECTION OF TEETH

(NOTE: For most general purpose work use a blade that has 12 teeth per inch; however, a fine-tooth blade should be used to cut thin stock. Keep the three-tooth rule--at least three teeth in contact with work--in mind when selecting saw blades. See Figure 5.)

FIGURE 5



JOB SHEET #1

E. Put the saw blade in the v-groove

F. Hold the saw firmly by the handle and the front of the frame

G. Start a back-and-forth movement of the saw and apply pressure on the forward stroke; lift the saw slightly on the return strokes

(NOTE: Use the entire length of blade when cutting.)

H. Cut at about 40 strokes per minute

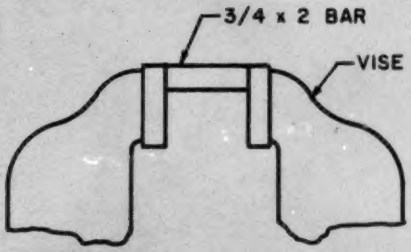
(CAUTION: When the saw is about to cut through the stock, ease up on the pressure. Otherwise you may push your hand into the sharp edge of the stock still held in the vise.)

I. Keep this part for future use

J. Repeat steps A through I and cut 3/16" steel bar 3 1/16" long

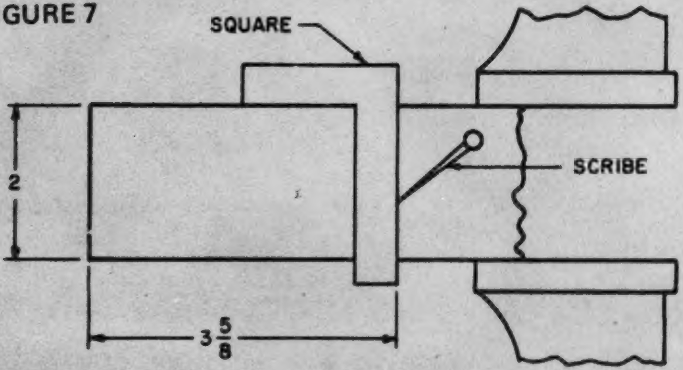
K. Clamp 3/4" x 2" flat stock in vise with about 5" extending past edge of vise with 2" inch side up (Figure 6)

FIGURE 6



L. Measure 3 5/8" on part and scribe a line square to the side to guide you when cutting (Figure 7)

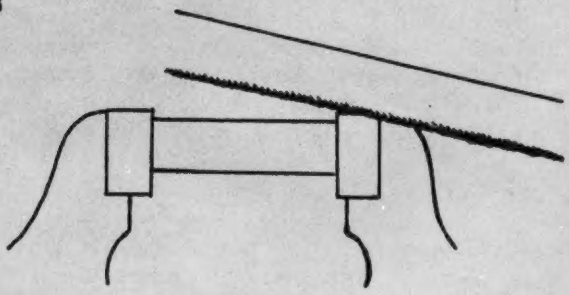
FIGURE 7



JOB SHEET #1

M. Saw this part off by repeating steps B through J (Figure 8)

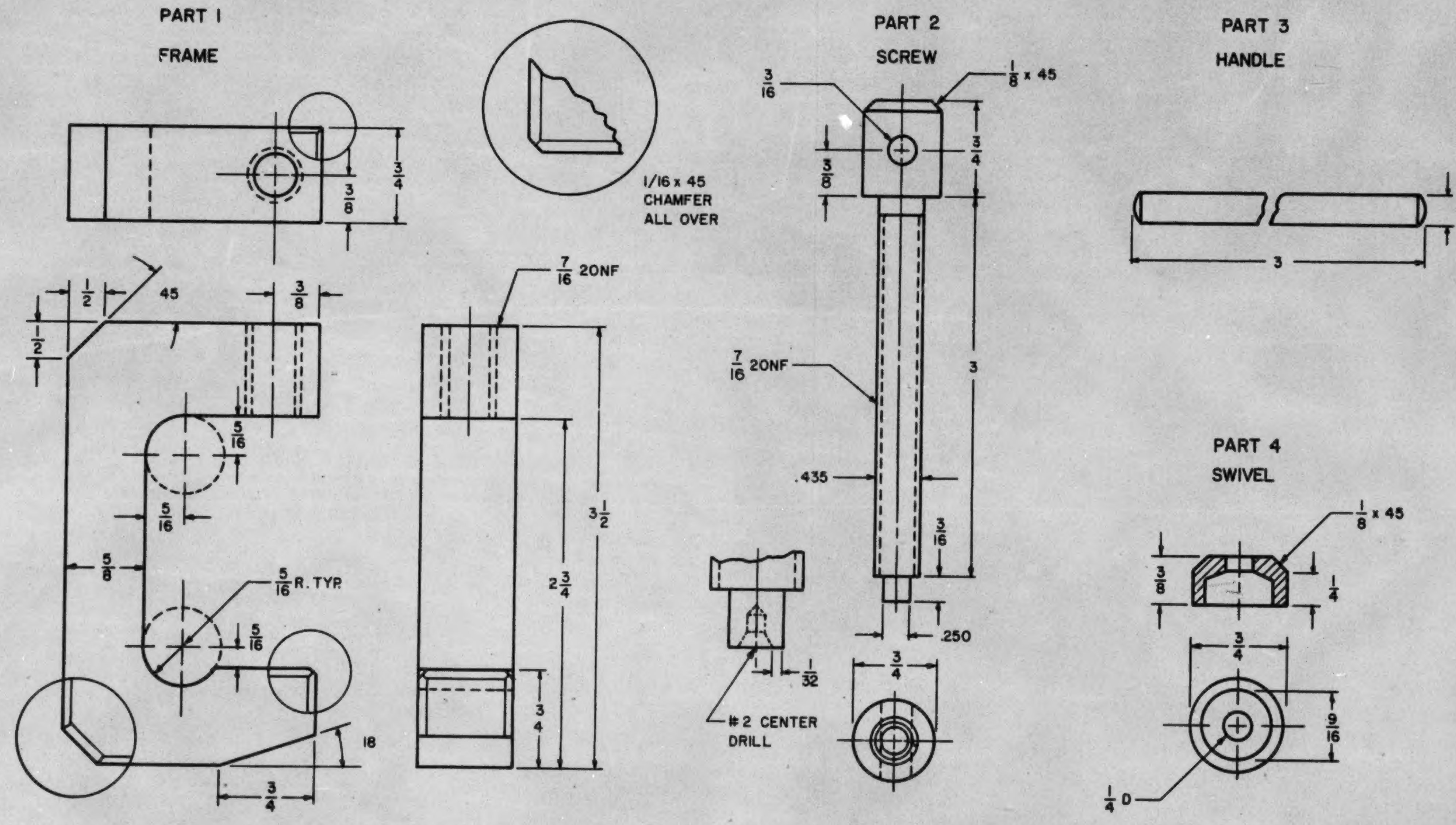
FIGURE 8



N. Deburr and turn parts into instructor

O. Put away tools and leftover stock, and clean up work area

JOB SHEET #1


PART 1
FRAME
1/16 x 45
CHAMFER
ALL OVER
1/2
45
3/8
1/2
5/16
5/16
5/8
5/16 R. TYP
5/16
3/4
18
3/4
3/8
7/16 20NF
3 1/2
2 3/4
3/4
PART 2
SCREW
3/16
1/8 x 45
3/8
3/4
7/16 20NF
3
.435
3/16
.250
1/32
#2 CENTER
DRILL
3/4
PART 3
HANDLE
3/16
3
PART 4
SWIVEL
1/8 x 45
3/8
1/4
3/4
9/16
1/4 D

NAME	MATERIAL	CUT SIZE
FRAME	1018 C.R.S.	2 x 3/4 x 3 5/8
SCREW	1018 C.R.S.	3/4 x 5
SWIVEL	1018 C.R.S.	
HANDLE	1018 C.R.S.	1/4 x 3 1/16

BENCH AND TOOL PROJECT #1

TOLERANCE	DRAWN BY	J D	"C" CLAMP
FRACTIONAL ± 1/64 ANG 10	CHECKED BY		SCALE 1-1
DEC XXX = ± .002	DATE 7-14-77		NUMBER 81001

HAND TOOLS
UNIT I

JOB SHEET #2--USE FILE TO SQUARE A PART TO SIZE

I. Tools and equipment

A. 10 or 12" double cut file with handle

B. 10 or 12" single cut file with handle

C. File card

D. Bench vise (mounted) with soft jaws

E. Combination square set or steel square

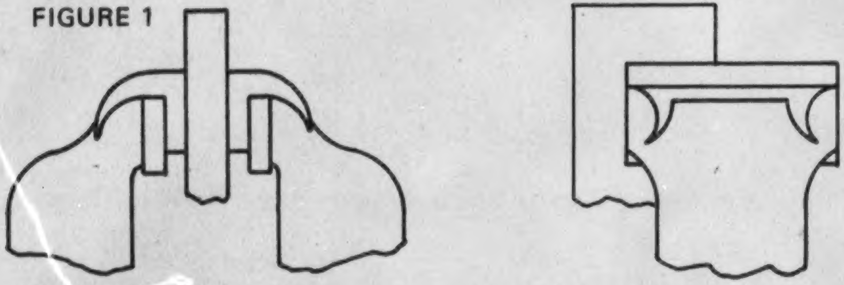
F. Chalk

G. Blueprint of C-clamp

II. Procedure

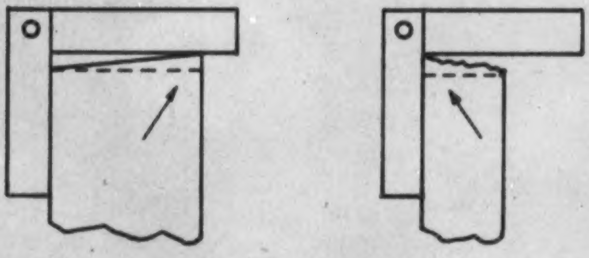
A. Mount previously cut steel bar (3/4" x 2" x 3 5/8") in vise with soft jaws so sawed end is up (Figure 1)

FIGURE 1



B. Use square to examine part so you will know where to start filing to square up part (Figure 2)

FIGURE 2

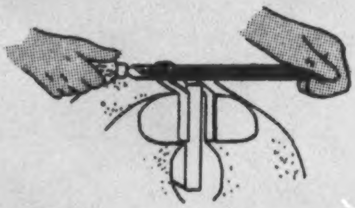


(NOTE: It is helpful to scribe a line as a reference line to help let you know when you are getting close.)

JOB SHEET #2

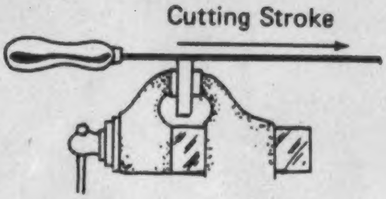
C. Pick up the double cut file; with handle of file in one hand place palm of other hand on top of file (Figure 3)

FIGURE 3



D. Push the file forward with pressure applied on the forward stroke so teeth of file cut the metal (Figure 4)

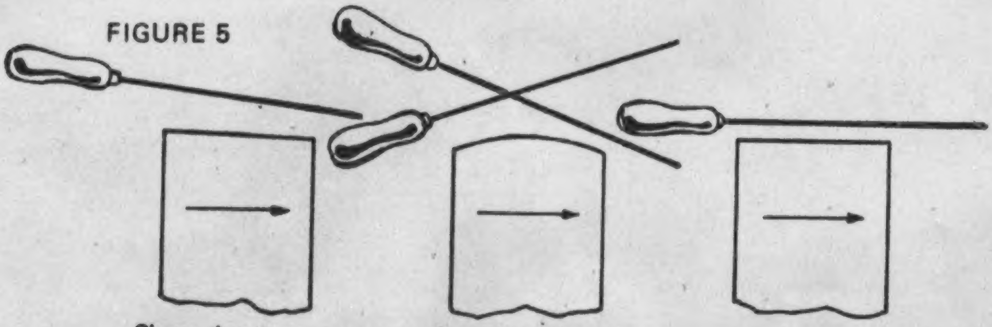
FIGURE 4



E. Keep the file flat on the forward stroke and control the cut

(NOTE: If the pressure is not even the cut will not be flat. See Figure 5.)

FIGURE 5



Slope due to not holding file level

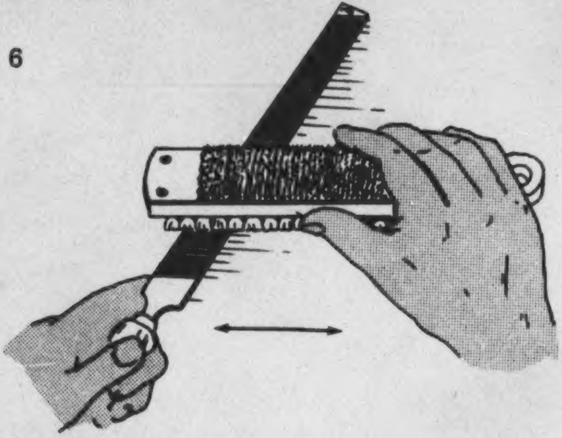
Rounded due to applying pressure at start and end of cut

Pressure even and file controlled

JOB SHEET #2

F. Clean the file by brushing it with the file card in the direction or slant of the cutting teeth (Figure 6)

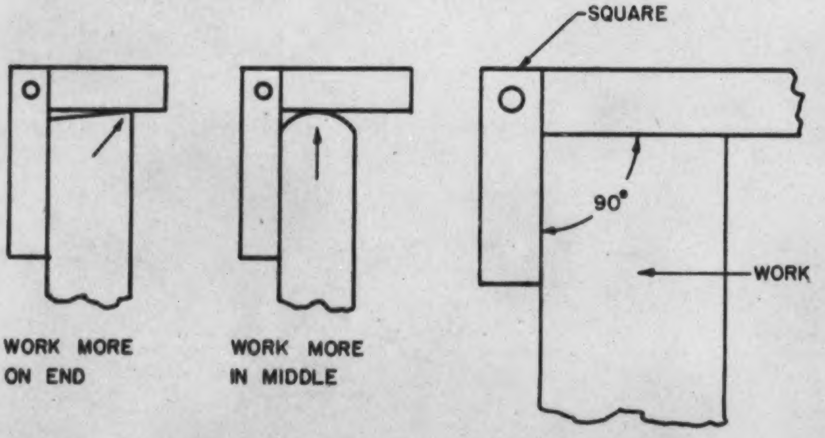
FIGURE 6



(NOTE: If the file is not kept clean it will not cut, and the filings will make marks in your work.)

G. Check the work with the square frequently so you know where metal needs to be removed (Figure 7)

FIGURE 7



WORK MORE ON END

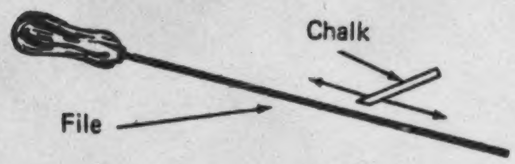
WORK MORE IN MIDDLE

WORK IS SQUARE WHEN THERE IS NO SPACE UNDER THE BLADE OF THE SQUARE

JOB SHEET #2

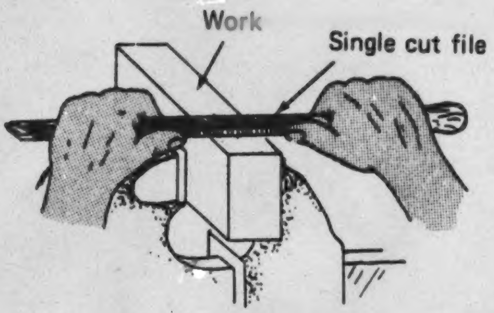
H. Get the single cut file and rub chalk on the teeth to keep the filings from sticking between the teeth of the file (Figure 8)

FIGURE 8



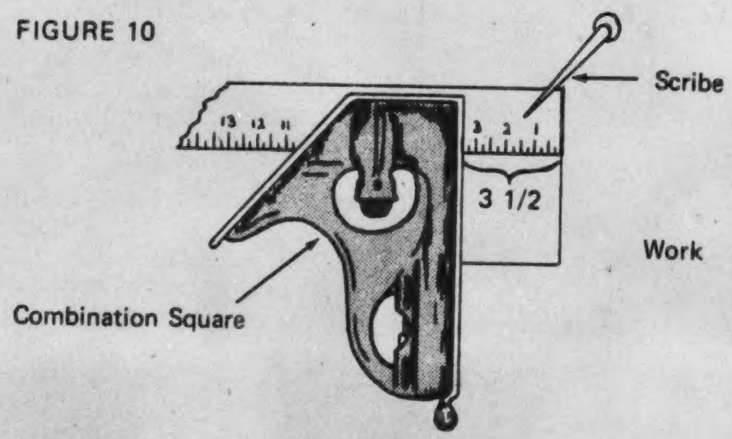
I. Drawfile the work to take out file marks by holding each end of the file and pushing the file and applying pressure on forward stroke (Figure 9)

FIGURE 9


Work
Single cut file

J. Set the combination square on 3 1/2" and scribe line using finished end of work as reference edge (Figure 10)

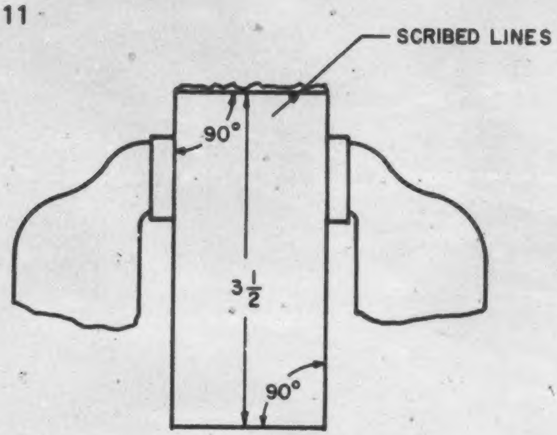
FIGURE 10


Scribe
13 12 11
3 2 1
3 1/2
Work
Combination Square

JOB SHEET #2

K. Use this scribed line to help you file the end square and to size as indicated below (Figure 11)

FIGURE 11


SCRIBED LINES
90°
$3\frac{1}{2}$
90°

L. Have instructor check file job for size and squareness

HAND TOOLS
UNIT I

JOB SHEET #3--PERFORM LAYOUT WITH COMBINATION SQUARE SET

I. Tools and equipment

- A. Combination square set
- B. Scribe
- C. Divider
- D. Hammer
- E. Center punch
- F. Layout fluid
- G. 3/4" x 2" x 3 1/2" steel part (Frame of C-clamp)
- H. Blueprint of C-clamp
- I. File
- J. Cleaning solvent
- K. Clean rag

II. Procedure

A. Prepare work for layout by filing off any sharp edges and removing all oil with solvent

B. Apply layout solution

1. Use the brush and paint the 2" x 3 1/2" surface of the work with a thin coat of layout fluid

   (NOTE: Use a rag to remove the excess fluid. If fluid is allowed to dry in heavy layers it will chip off when you are scribing lines.)

2. If the layout solution is in a spray can, set part on paper and spray a thin coat on 2" x 3 1/2" surface

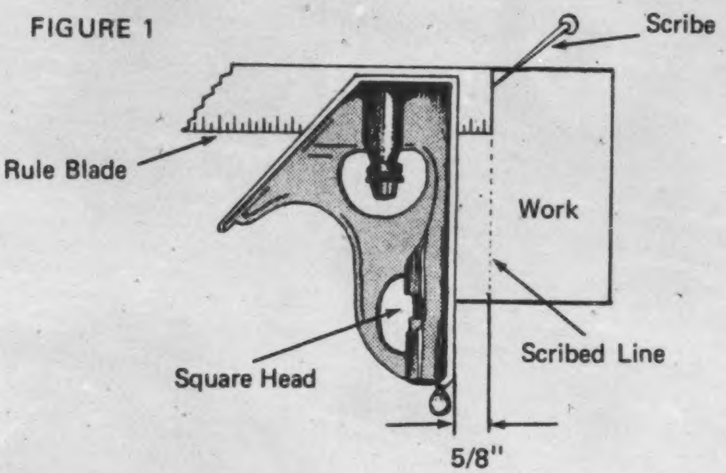
   (CAUTION: This solution will stain clothing and is hard to remove from hands, so be careful when using.)

C. Allow solution to dry thoroughly

JOB SHEET #3

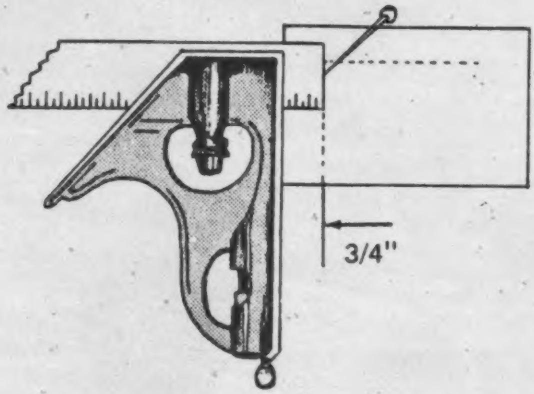
D. Set square head so blade protrudes 5/8" and scribe line down length of side (Figure 1)

FIGURE 1


Scribe
Rule Blade
Work
Scribed Line
Square Head
5/8"

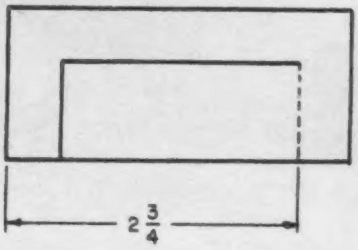
E. Set square to 3/4" and scribe bottom line (Figure 2)

FIGURE 2



F. Set square to 2 3/4" and scribe line (Figure 3)

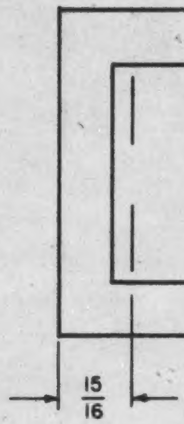
FIGURE 3



JOB SHEET #3

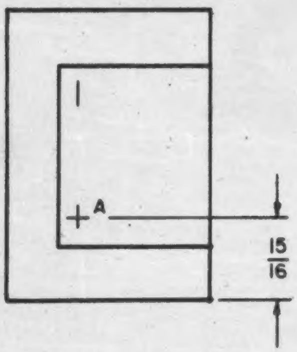
G. Set square to 15/16" and scribe lines for location of 5/16" radius (Figure 4)

FIGURE 4



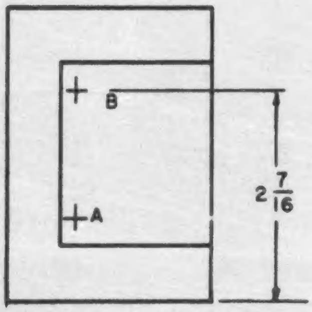
H. Set square on 15/16" and scribe center at location A (Figure 5)

FIGURE 5



I. Set square at 2 7/16" and scribe center at location B (Figure 6)

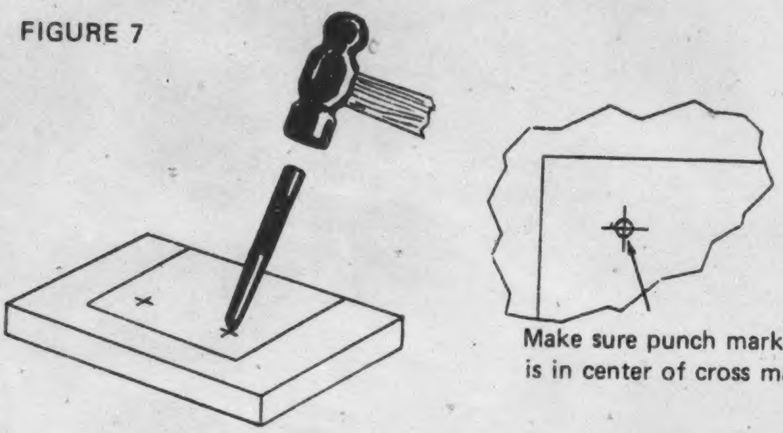
FIGURE 6



JOB SHEET #3

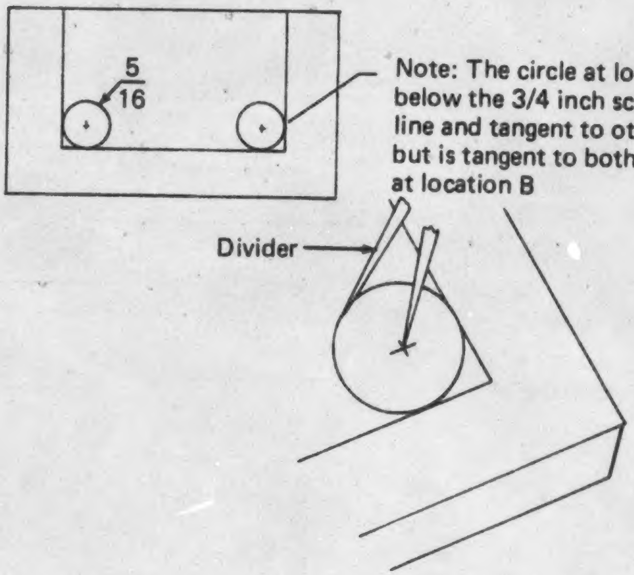
J. Set part down on bench, and use a center punch and hammer to make a shallow punch mark where the lines intersect (Figure 7)

FIGURE 7


Make sure punch mark
is in center of cross marks

K. Set divider points 5/16" apart and scribe circle (Figure 8)

FIGURE 8

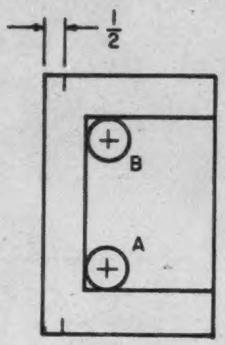


Note: The circle at location A is
below the 3/4 inch scribed
line and tangent to other line
but is tangent to both lines
at location B

JOB SHEET #3

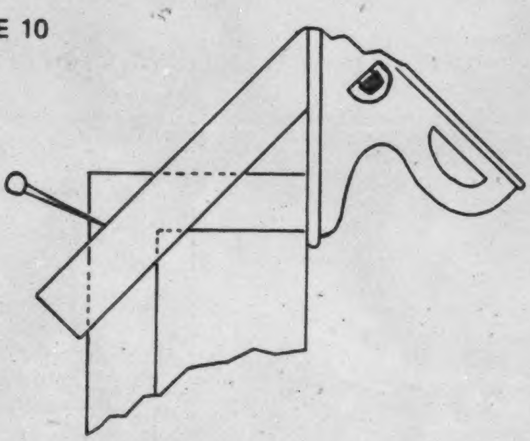
L. Set square at 1/2" and scribe mark at each end from back side (Figure 9)

FIGURE 9



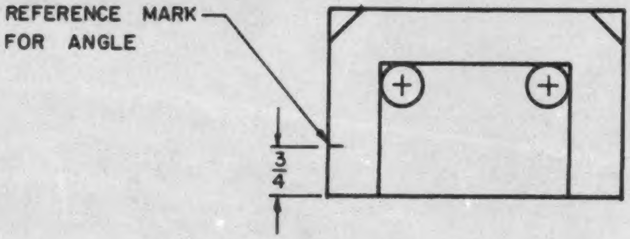
M. Use 45° side of square and scribe the angled lines at both ends (Figure 10)

FIGURE 10



N. Set square on 3/4" and scribe reference mark for angle (Figure 11)

FIGURE 11

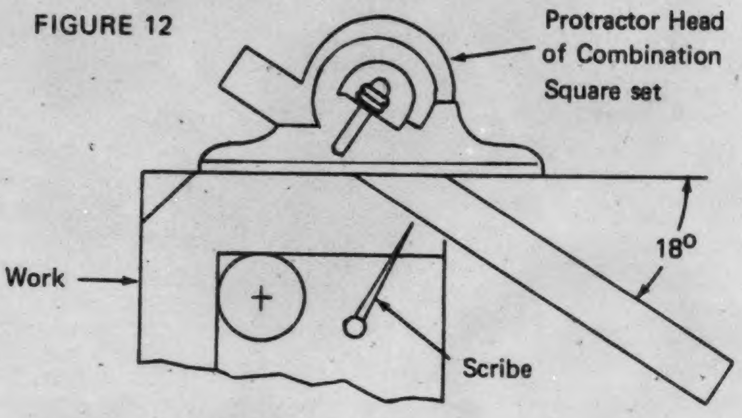


O. Take the square head off and put the protractor head on; set it at 18°

JOB SHEET #3

P. Scribe line for 18° angle (Figure 12)

FIGURE 12


Protractor Head of Combination Square set
18°
Work
Scribe

Q. Use metal stamp to stamp your initials on the part

R. Turn part in to instructor so holes can be drilled

HAND TOOLS
UNIT I

JOB SHEET #4--HACKSAW TO LAYOUT

I. Tools and equipment

  A. Hand hacksaw

  B. Part 1 of C-clamp which has been pre-drilled

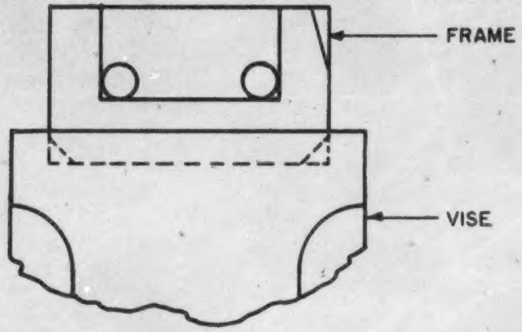
  C. Bench vise with soft jaws

  D. File

II. Procedure

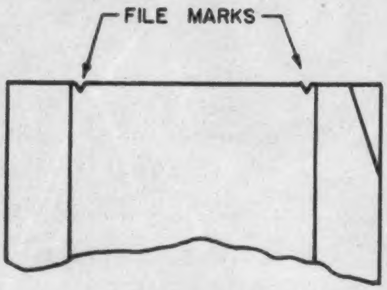
  A. Clamp frame in bench vise so open part of frame is up (Figure 1)

FIGURE 1



  B. Use file to make notches for saw blade so when you cut out the section you leave layout lines (Figure 2)

FIGURE 2

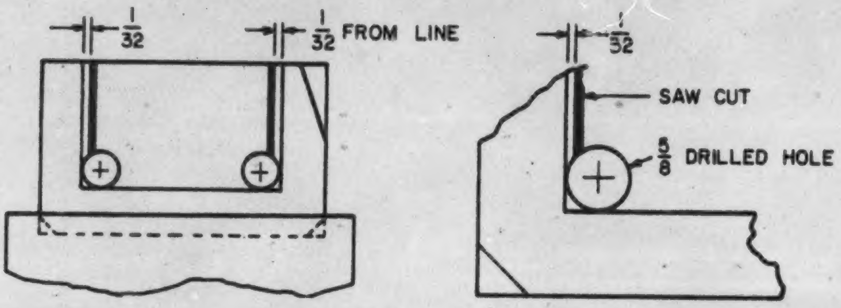


JOB SHEET #4

C. Grasp the hacksaw and cut down to the holes (Figure 3)

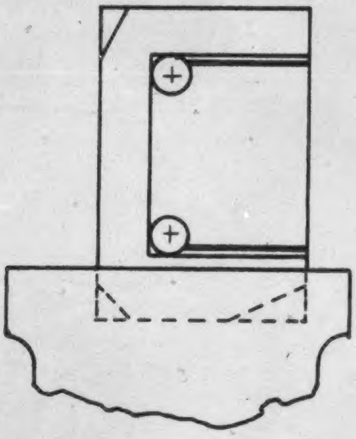
(NOTE: Ease up on the pressure when you are about to cut into the holes, as part of the hole is not to be cut.)

FIGURE 3


1/32
1/32 FROM LINE
1/32
SAW CUT
5/8 DRILLED HOLE

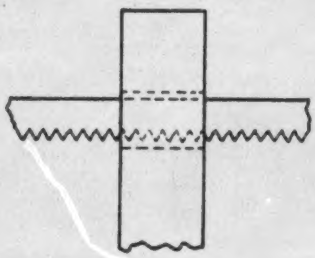
D. Turn part in vise so it is clamped on the bottom of the frame (Figure 4)

FIGURE 4



E. Insert hacksaw blade in frame and turn so you can cut down to other hole (Figure 5)

FIGURE 5



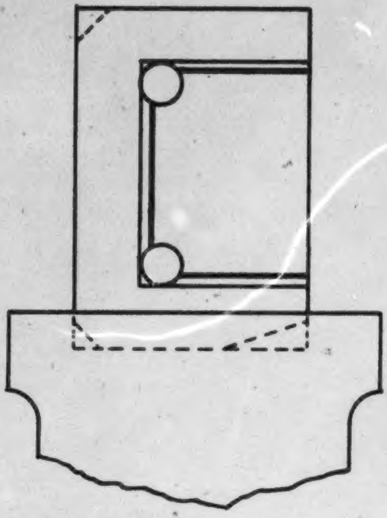
JOB SHEET #4

F. Take short strokes until you have the saw started where you want it to cut (Figure 6)

(NOTE: When making this cut you will have to saw at a slight angle and then work the cut straight.)

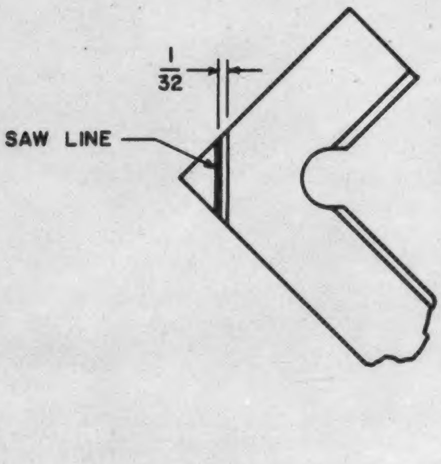
(CAUTION: Do not try to force the cut straight too soon or you will bend the saw blade.)

FIGURE 6



G. Turn part in vise so cut is in down direction and cut each angle (Figure 7)

FIGURE 7



HAND TOOLS
UNIT I

JOB SHEET #5--FILE TO LAYOUT

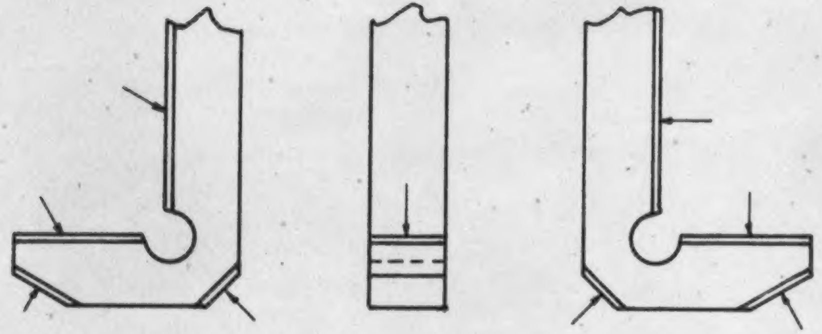
I. Tools and equipment

- A. 10 or 12" single cut file with handle
- B. 10 or 12" double cut file with handle
- C. 8" half-round file with handle
- D. 4 or 6" steel square
- E. Bench vise with soft jaws
- F. Combination square set with scribe

II. Procedure

A. Use combination square and lay out all straight and angled lines on other side of part for reference purposes (Figure 1)

FIGURE 1



(NOTE: Arrows indicate saw cut, and inside lines denote finished size of part.)

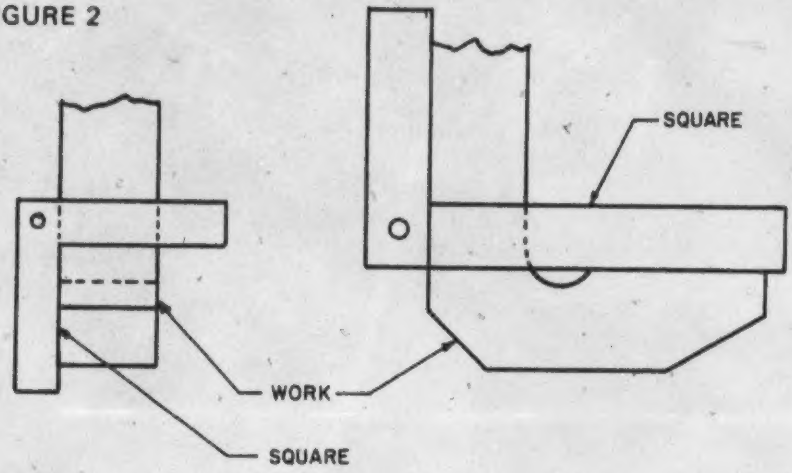
B. Use double cut file to remove large amounts of material until you are almost to line

(NOTE: Use layout lines scribed on both sides to help keep file flat and straight.)

JOB SHEET #5

C. Use single cut file and drawfile to size, checking occasionally with square (Figure 2)

FIGURE 2

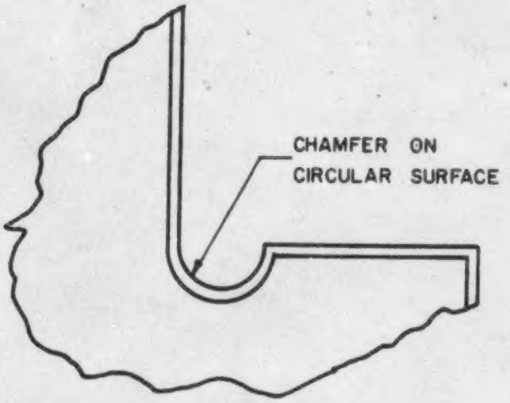

SQUARE
WORK
SQUARE

(NOTE: Check all sides for squareness.)

D. File angles and check with protractor and square

E. Use half round file and file chamfered area around radius (Figure 3)

FIGURE 3


CHAMFER ON
CIRCULAR SURFACE

F. Use single cut file and file chamfer on all other surfaces

HAND TOOLS
UNIT I

JOB SHEET #6--PRODUCE INTERNAL THREADS BY HAND TAPPING

I. Tools and equipment

A. 7/16-20NF taper tap

B. Tap wrench

C. Cutting fluid for tapping

D. Steel rule or square

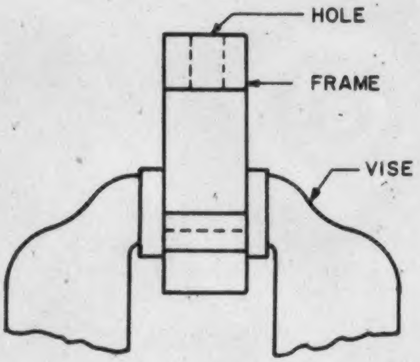
E. Bench vise with soft jaws

F. Frame (Part 1) of C-clamp

II. Procedure

A. Clamp frame in vise so hole is up (Figure 1)

FIGURE 1



(NOTE: Hole has been drilled to 25/64" diameter.)

B. Use a taper tap (7/16-20NF) and fasten it securely in the tap wrench

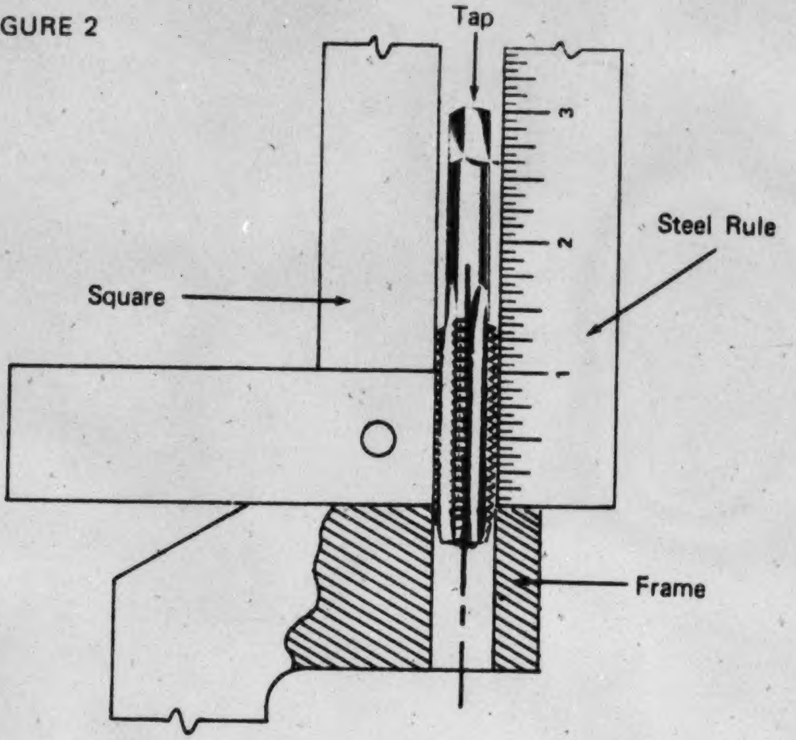
C. Put the tap in the hole that has been drilled to the tap drill size, and apply a steady downward pressure while turning the tap wrench clockwise; screw the tap in the hole about two turns

D. Loosen the tap wrench and remove it from the tap, making sure not to move the tap out of line

JOB SHEET #6

E. Check the tap to see if it is square to the work with a steel rule or square (Figure 2)

FIGURE 2



F. If the tap is not square, put the tap wrench back on, and back the tap out of the hole a little; straighten it by applying side pressure and screw it back in the hole; then recheck for squareness

G. When the tap is started in the hole straight, apply cutting fluid to the tap

H. Screw the tap in the hole one or two complete revolutions and back it out one turn or until you feel the chip break; then continue to screw the tap into the work

I. Continue to screw tap in work and back out to break chips until the tap turns free, producing threads though the length of the hole

J. Turn the tap counterclockwise and remove tap from work

K. Clean off tap and put up all tools

(NOTE: Tapping may also be done on a drill press. This will be explained in the unit on Drill Press.)

HAND TOOLS
UNIT I

JOB SHEET #7--PRODUCE EXTERNAL THREADS WITH HAND DIE

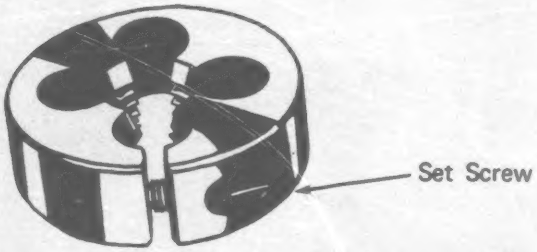
I. Tools and equipment

- A. Cutting fluid
- B. 7/16-20 die and die stock
- C. Screw blank (Part 2 of C-clamp)
- D. Bench vise with soft jaws
- E. 7/16-20 NF bolt
- F. Bench grinder

II. Procedure

- A. Grasp the bolt in one hand and the die in the other and screw the die on the bolt
- B. If the die starts to cut the threads on the bolt it is adjusted too small and needs to be adjusted larger. If it is too loose it will also need to be adjusted
    1. Turn the set screw clockwise to make it looser or counterclockwise to make it tighter
    2. Check it on the bolt; it should be adjusted so it is tight but does not cut the threads on the bolt (Figure 1)

FIGURE 1

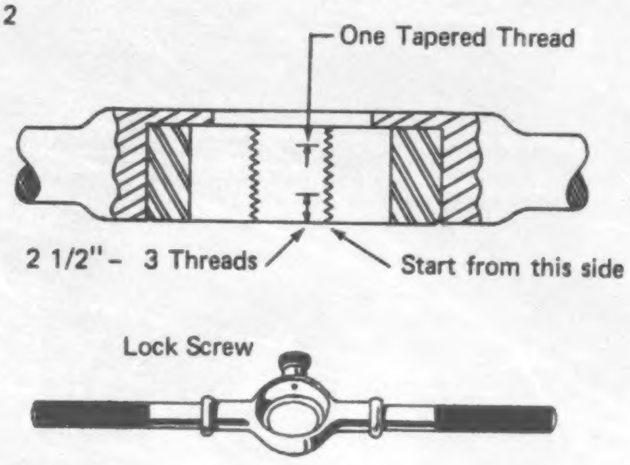


JOB SHEET #7

C. Put the die in the die stock and the lock screw on the die, with the taper of the die down (Figure 2)

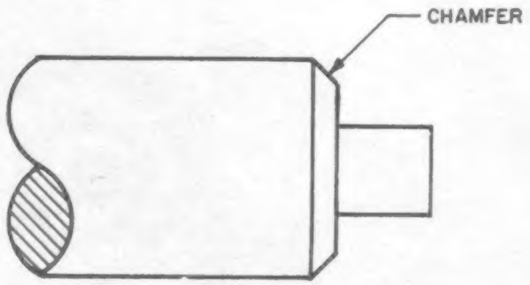
(NOTE: Make sure the lock screw is aligned with the recess of the die.)

FIGURE 2


One Tapered Thread
2 1/2" - 3 Threads
Start from this side
Lock Screw

D. Chamfer the end slightly with the bench grinder to make it easier for the die to start (Figure 3)

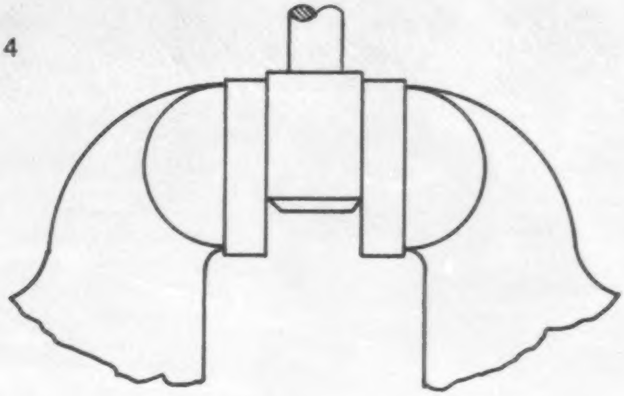
FIGURE 3



JOB SHEET #7

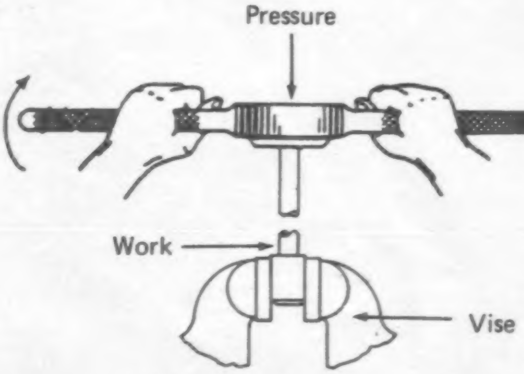
E. Clamp the part to be threaded in bench vise so the screw is vertical (Figure 4)

FIGURE 4



F. Put the tapered side of the die on the work with both hands near the die; hold the die stock level or square to the work, press down firmly, and turn the die stock in a clockwise direction (Figure 5)

FIGURE 5



(NOTE: As soon as the die has started on work [one or two turns] check to make sure it is started on straight; if not, apply more pressure on high side.)

G. Apply cutting fluid and cut threads until the die is on the shoulder; make one or two revolutions and back up one to break the chip

H. Back the die all the way off, and clean the die and remove from diestock

I. Wipe off all cutting fluid from work and tools and put up in proper place

JOB SHEET #7

J. Clean vise and floor of chips and cutting fluids

K. Screw part into threaded protion of frame; if it does not fit, adjust the die smaller and repeat steps C through H

HAND TOOLS
UNIT I

JOB SHEET #8–ASSEMBLE C-CLAMP

I. Tools and equipment

   A. Bench vise

   B. Ball peen hammer

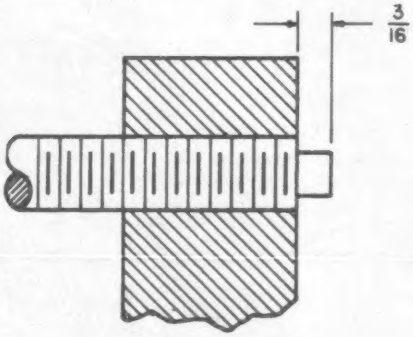
   C. Cold chisel

   D. Parts 1, 2, and 3 of C-clamp

II. Procedure

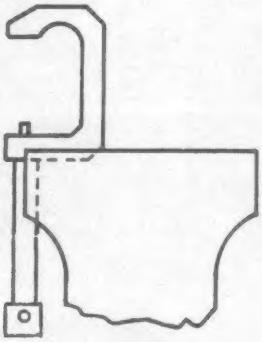
   A. Insert the screw in the frame until the smaller diameter of the screw is through the frame (Figure 1)

FIGURE 1



   B. Clamp frame in vise as pictured below (Figure 2)

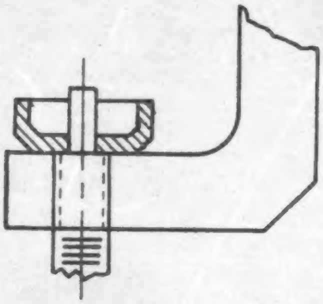
FIGURE 2



JOB SHEET #8

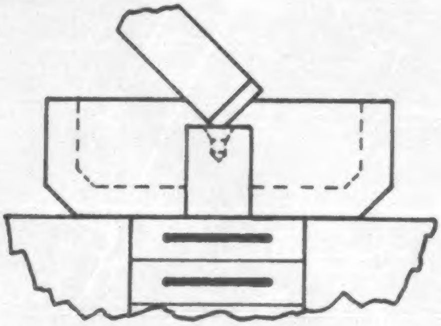
C. Set the swivel (Part 3) on the recessed part of the bolt (Figure 3)

FIGURE 3



D. Use cold chisel to secure the swivel to the screw by inserting the cutting edge of the chisel on the center drilled hole; tap the head of the chisel lightly with the hammer (Figure 4)

FIGURE 4



E. Repeat step D three more times, making small marks at approximately 90° angles to each other

(CAUTION: Do not cut so deeply with chisel that the swivel will not turn.)

F. Put all tools up and turn C-clamp into your instructor for evaluation

HAND TOOLS
UNIT I

TEST

NAME ______________________________ SCORE ______________

1. Match terms associated with hand tools to the correct definitions. Write the correct numbers in the blanks provided.

_____a. Easy to break

_____b. Producing a chip by using a chisel

_____c. An angled surface

_____d. The pointed end of a file

_____e. Process of making metal resistant to wear

_____f. The enlarged area on the end of a chisel, caused by striking it with a hammer

_____g. The sharp edge left on a metal part from a machining operation

_____h. The cutting action of a tool

_____i. Harm to an individual

_____j. A semi-precision steel rule with graduations

_____k. Pushing and pulling a file sideways along the work

_____l. The side from which dimensions are taken or made

_____m. Tool used to produce external threads

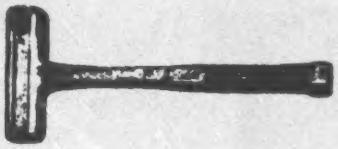
_____n. The size a hole is drilled for a specific size tap

_____o. A thin, colored lacquer that is painted or sprayed on the surface of a part so layout lines can be seen clearly

1. Chipping
2. Mushroom
3. Tang
4. Shearing
5. Drawfiling
6. Burr
7. Hardening
8. Brittle
9. Personal injury
10. Reference surface
11. Tap drill size
12. Threading die
13. Scale
14. Layout solution
15. Chamfer

2. Label non-cutting hand tools with their appropriate name and use. Write the correct names and descriptions in the blanks.

a.



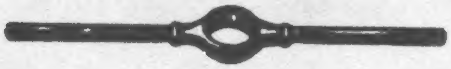
____

Use-- ________________________

____

____

b.



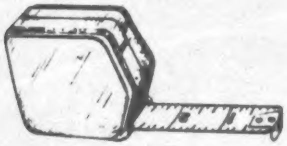
____

Use-- ________________________

____

____

c.



____

Use-- ________________________

____

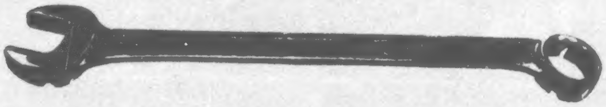
d.

____

Use-- ________________________

____

e.

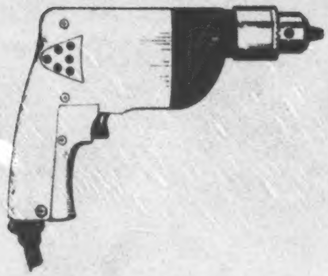


____

Use-- ________________________

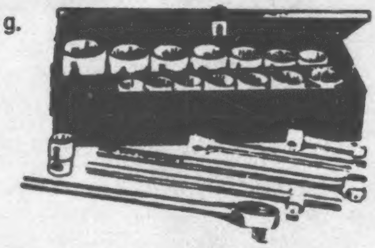
____

f.



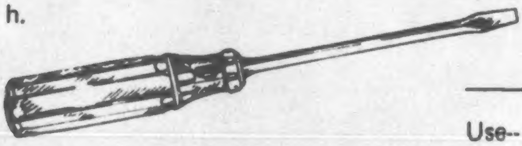
Use--

g.



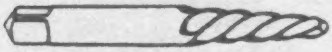
Use--

h.



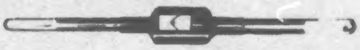
Use--

i.



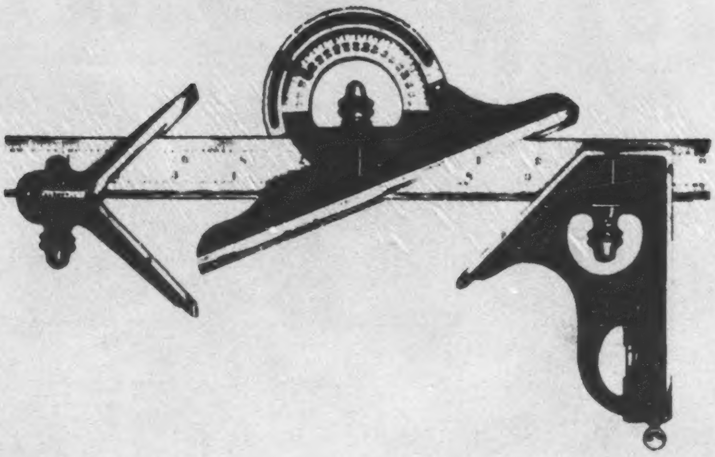
Use--

j.



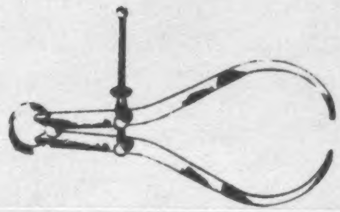
Use--

k.



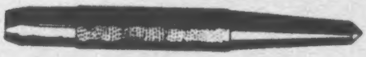
Use--

l.



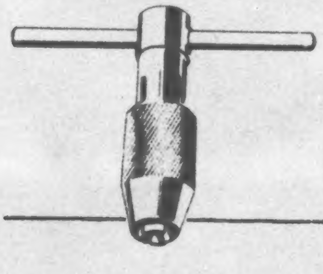
Use--

m.



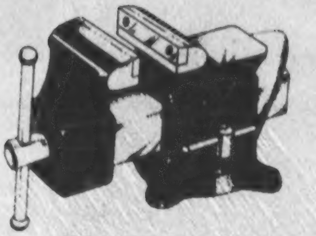
Use--

n.



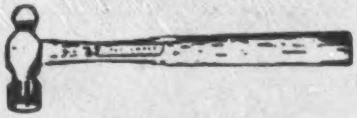
Use--

o.



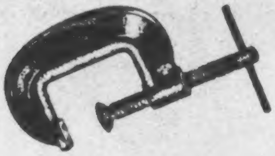
Use-- ____________________

p.



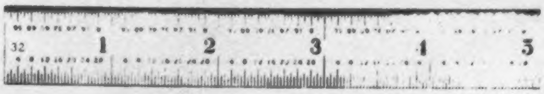
Use-- ____________________

q.



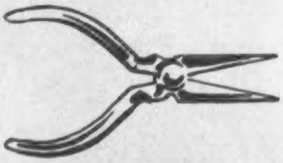
Use-- ____________________

r.



Use-- ____________________

s.

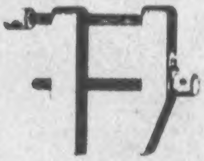


Use-- ____________________

t.

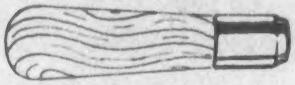
Use-- ____________________

u.



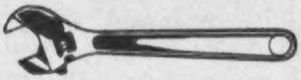
Use-- ____________________

v.



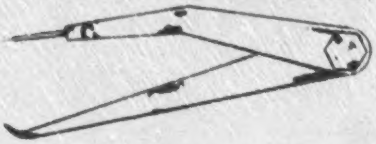
Use-- ____________________

w.



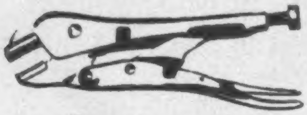
Use--

x.



Use--

y.



Use--

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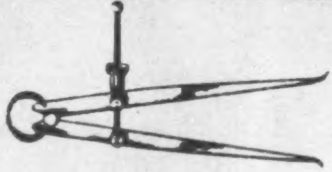
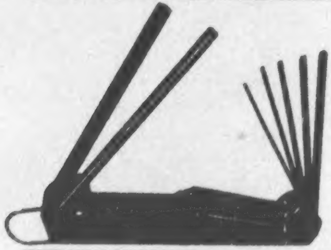


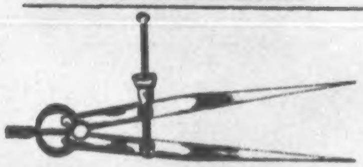
Use--

aa.



Use--

bb.



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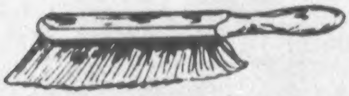
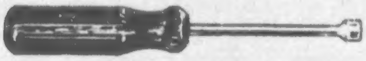
cc.



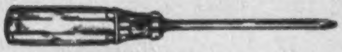
Use--

dd.



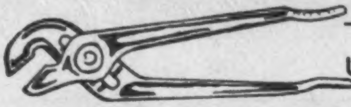
Use--

ee.



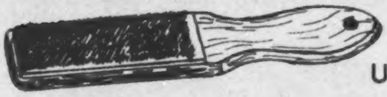
Use --

ff.



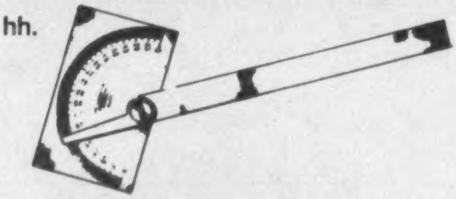
Use --

gg.



Use --

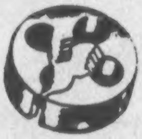
hh.



Use --

3. Label cutting hand tools with their appropriate name and use. Write the correct names and descriptions in the blanks.

a.



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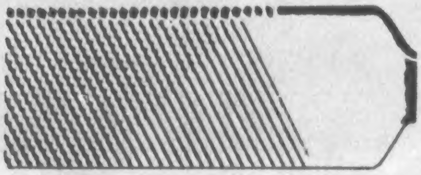
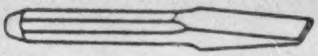
b.



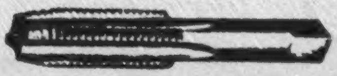
Use--

c.



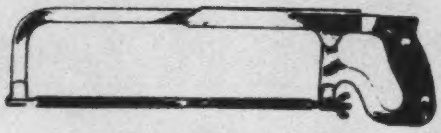
Use--

d.



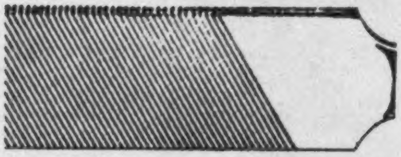
Use--

e.



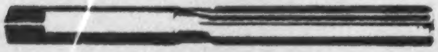
Use--

f.



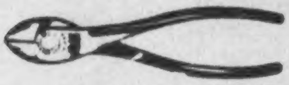
Use--

g.



Use--

h.

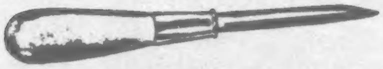


Use--

i.

Use--

j.



Use--

4. State rules for safe use of hand tools.

a. Machinist's bench vise--

b. Wrenches--

c. Pliers--

d. Files--

e. Screwdrivers-- ____________________

____

____

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f. Chisels-- ____________________

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g. Cleaning chips from work-- ____________________

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h. Hand hacksaws-- ____________________

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i. General-- ____________________

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j. Hammers– ______

5. State five rules for care of hand tools in the spaces below.

a. ______

b. ______

c. ______

d. ______

e. ______

6. Describe five reasons for tap failure in the blanks below.

a. ______

b. ______

c. ______

d. ______

e. ______

7. Determine the tap drill size for the following taps from the tap drill chart given. Write the correct answers in the blanks provided.

MACHINE SCREW SIZES			UNC and UNF	
NOMINAL SIZE TAP	RECOMMENDED TAP DRILL		PROBABLE HOLE SIZE	% THREAD
	DRILL	DEC.		
0-80	3/64	.0469	.0484	71
1-64	53	.0595	.0610	59
1-72	53	.0595	.0610	67
2-56	50	.0700	.0717	62
2-64	50	.0700	.0717	70
3-48	47	.0785	.0804	69
3-56	46	.0810	.0829	69
4-40	43	.0890	.0910	65
4-48	42	.0935	.0955	61
5-40	38	.1015	.1038	65
5-44	37	.1040	.1063	63
6-32	36	.1065	.1091	71
6-40	33	.1130	.1156	69
8-32	29	.1360	.1389	62
8-36	29	.1360	.1389	70
10-24	26	.1470	.1502	74
10-32	21	.1590	.1622	68
12-24	16	.1770	.1805	66
12-28	15	.1800	.1835	70

FRACTIONAL SIZES			UNC and UNF	
NOMINAL SIZE TAP	RECOMMENDED TAP DRILL		PROBABLE HOLE SIZE	% THREAD
	DRILL	DEC.		
1/4-20	7	.2010	.2048	70
1/4-28	3	.2130	.2168	72
5/16-18	F	.2570	.2608	72
5/16-24	1	.2720	.2761	67
3/8-16	5/16	.3125	.3169	72
3/8-24	Q	.3320	.3364	71
7/16-14	U	.3680	.3726	70
7/16-20	25/64	.3906	.3952	65
1/2-13	27/64	.4219	.4266	73
1/2-20	29/64	.4531	.4578	65
9/16-12	31/64	.4844	.4892	68
9/16-18	33/64	.5156	.5204	58
5/8-11	17/32	.5312	.5361	75
5/8-18	37/64	.5781	.5831	58
3/4-10	21/32	.6562	.6612	68
3/4-16	11/16	.6875	.6925	71
7/8-9	49/64	.7656	.7708	72
7/8-14	13/16	.8125	.8177	62
1-8	7/8	.8750	.8809	73
1-12	59/64	.9219	.9279	67

a. #10-24NC ____________________

b. 1/4-20NC ____________________

c. 3/4-16NF ____________________

d. Calculate the following tap drill size using the correct shop formula. Show your work.

1) 5/16-18NC for 75% thread = ________ 2) 1 1/2-6NC for 65% thread = ______

8. Complete hand tool safety test.

9. Plan procedures for completing shop projects.

10. Demonstrate the ability to:
    a. Use a hand hacksaw.
    b. Use file to square a part to size.
    c. Perform layout with combination square set.
    d. Hacksaw to layout.
    e. File to layout.
    f. Produce internal threads by hand tapping.
    g. Produce external threads with hand die.
    h. Assemble C-clamp.

    (NOTE: If activities 8 - 10 have not been finished before the test, ask your instructor when they should be completed.)

HAND TOOLS
UNIT I

ANSWERS TO TEST

(NOTE: The point system designated in parentheses is intended to be a guideline and should be adapted as needed. The point total is 545.)

1. (30 points)

   a. 8
   b. 1
   c. 15
   d. 3
   e. 7
   f. 2
   g. 6
   h. 4
   i. 9
   j. 13
   k. 5
   l. 10
   m. 12
   n. 11
   o. 14

2. (100 points)

   a. Soft face mallet--Used for moving objects by tapping; made of rubber, plastic, or rawhide so it does not damage the part or attachment being struck

   b. Die stock--Used to hold round threading dies when cutting threads by hand

   c. Steel tape rule (tape measure)--Used to measure long dimensions or contoured surfaces to 1/32" accuracy

   d. Pin spanner wrench--Used to tighten or loosen nut that have holes instead of flats that fit the pin

   e. Combination (open and box end) wrench--Used to tighten or loosen square and hexagon head bolts of a particular size; prevents slippage

   f. Electric hand drill motor (hand-held)--Used to drill or ream holes and is semi-portable

   g. Socket wrench set--Used to tighten or loosen bolts and nuts with hexagonal heads, usually in places where space is limited

   h. Standard screwdriver--Used to tighten or loosen a screw that has a slotted head

   i. Screw extractor ("easy-out")--Used to remove bolts and screws whose heads have been broken off or damaged

   j. Tap wrench--Used to drive taps, hand reamers, and screw extractors of larger sizes (3/8" and up)

k. Combination square set--Used to lay out straight and angular dimensions, measure and check angles, check for squareness, and locate center of round parts

l. Outside caliper--Used to measure outside diameters

m. Center punch--Used to mark the location of a hole prior to drilling by making a dent in the surface of the material

n. Tap handle--Used to drive taps, hand reamers, and screw extractors

o. Machinist's bench vise--Used to hold parts for sawing, filing, or other hand operations

p. Ball peen hammer--Used to drive a chisel or flair a pin

q. C-clamp--Used to hold one part to another by pressure of a screw and anvil

r. Steel rule (scale)--Used to measure lengths and to set semi-precision tools like dividers

s. Long nose pliers--Used for placing or removing small items in narrow spaces, and when twisting and bending wire during electrical repairs

t. Offset screwdriver--Used to tighten or loosen screws in places where height is limited

u. Parallel clamp--Used when holding two precision parts together with two parallel jaws

v. File handle--Used to cover the tang of a file

w. Adjustable wrench--Used to loosen or tighten bolts and nuts; one size fits many

x. Firm joint hermaphrodite caliper--Used for layout from a reference surface; must be set with a scale

y. Locking pliers (vise-grips)--Used to lock on a part when turning; have a mechanical pressure and lock system

z. Inside caliper--Used to measure inside diameters and widths of slots

aa. Hex key set--Used to tighten or loosen socket head screws

bb. Divider--Used to lay out circles, arcs, measure distance between points, and to transfer a measurement directly from a steel rule

cc. Counter or bench brush--Used when cleaning up bench or counter; has long fine bristles that will clean fine chips from work area

dd. Nut driver--Used to tighten or loosen small machine screws and nuts with hexagonal heads; the socket on the end is made to fit a particular size

ee. Phillips screwdriver--Used to tighten or loosen screws and bolts which have a head with four slots that slant downward

ff. Tongue and groove pliers--Used to tighten or loosen couplings or fittings gg. File card--Used to clean a file

hh. Protractor--Used to lay out or measure angles to an accuracy of one degree

3. (20 points)

a. Adjustable threading die--Used to produce external threads on stock of a particular size by hand; mounted in a die stock which holds and turns threading die

b. Double-cut (machinist's file)--Used whenever material must be removed rapidly

c. Cold chisel--Used for chipping flat surfaces and for cutting thin sheet metal

d. Tap--Used to produce internal threads in a hole that has been drilled to a specific size

e. Hand hacksaw--Used to saw metal parts to size or shape by hand

f. Single-cut (mill file)--Used for drawfiling, lathe work, and general purpose filing where a smooth finish is required

g. Hand reamer--Used when it is necessary to produce a hole that is accurate and smooth; designed to remove only .002" to .005" of material

h. Side cutters--Used to cut soft wire or steel bands

i. Tin snips--Used to cut thin sheet metal, shim stock, or band saw blade material to size or shape

j. Machinist's scraper (burr knife)--Used to remove burrs from holes, slots, grooves or edges of machined parts by hand

4. (50 points)

a. Machinist's bench vise

    1) Always clamp work well in the jaws

    2) Do not use a cheater bar or hammer to tighten vise

    3) Never hammer on vise guides; the casting will not stand the force

b. Wrenches

    1) Use wrench of correct size

    2) Adjustable wrenches should be used *only* as a last resort because they can slip, damaging the nut and possibly injuring the user

    3) It is safer to pull a wrench toward you than to push it away from you

c. Pliers

    1) Do not use pliers to loosen or tighten a bolt or nut; they will damage the head

   2) Never use pliers to grip finished surfaces because the teeth will score the work

   3) If you must use pliers on a bolt or nut, use locking pliers that will not slip as easily

d. Files

   1) Never use a file that is not equipped with a handle to prevent possible stab wounds from the spear-like point (tang)

   2) Never use a file as a pry bar; it will break and can cause injury

   3) When filing, apply pressure on forward stroke only

e. Screwdrivers

   1) Never use a screwdriver as a chisel because it will damage the screwdriver

   2) Never hold work when using a screwdriver; lay it on a bench or hold it in a vise; if the screwdriver slips it can cause a stab wound

   3) Always use a screwdriver that fits the head of the screw or you will damage the screw or screwdriver

f. Chisels

   1) Never use a chisel that has a mushroomed head as it can chip off and cause injury; grind the head smooth

   2) When using a chisel for chipping, always chip away from yourself and others

g. Cleaning chips from work

   1) Use a brush to clean chips from machine or work

   2) Never use air hose with high pressure to clean machine or work; chips can be blown into machinery or someone's eyes

h. Hand hacksaws

   1) Hold part in vise close to the vise jaws

   2) Ease up on the pressure when you are about to cut through the work so your hands will not strike work or vise

   3) Apply pressure only on forward stroke using the entire length of the blade

   4) Saw about 40 strokes per minute and do not bend the blade

i. General

   1) Report all damaged equipment to instructor

    2) Report all injuries to instructor
    3) Always store sharp pointed tools in a place where you will not stab yourself with them

j. Hammers

    1) Never use a hammer that has a split handle or loose head
    2) Never use a hammer on precision parts
    3) Never strike hard surfaces together; a piece may break off one of them and hurt someone or damage the parts

5. (10 points)

Any five of the following:

a. Always use tool to do work for which it was designed

b. Wipe chips and grease from tools before storing

c. Always store tools in proper place

d. Protect tools from rust; oil after using

e. Inspect tools to make sure they are in good working condition

f. Never use cheater bar on wrenches to get more leverage

6. (10 points)

Any five of the following:

a. A hole that has been drilled too small requires more pressure than the tap can stand

b. A tap that is not straight with the hole will bind

c. A dull tap requires excessive pressure

d. Not using cutting fluid when required will cause a tap to bind

e. Failure to back up and break the chip puts too much pressure on the tap

f. Failure to reverse direction of the tap once the point has reached the bottom of the hole will leave chip buildup

g. Using a too-large tap wrench will not let you feel how much torque you are applying

7. (25 points)

a. #26 drill

b. #7 drill

c. 11/16 drill

d. 1) .257 or .2585

    2) 1.3592

8. (40 points)

   Answers are at end of assignment sheets; students must score 100%

9. (60 points)

   Evaluated to satisfaction of instructor

10. (200 points--25 each job sheet)

    Performance skills evaluated to satisfaction of instructor

PEDESTAL GRINDER
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to use the pedestal grinder safely, identify different types of grinding wheels and the maintenance required for the pedestal grinder. This knowledge will be shown by completion of assignment sheets, job sheets, and unit test with a minimum score of 85 percent.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with the pedestal grinder and hand grinding to the correct definitions.
2. State rules that apply to safe use of the pedestal grinder.
3. Select the proper grinding wheel for different materials.
4. Interpret the composition of grinding wheels.
5. Describe care and storage of grinding wheels.
6. Match grinding problems to their possible causes and corrections.
7. Name jobs that are pedestal grinder operations.
8. Demonstrate the ability to:
    a. Check new grinding wheel for cracks.
    b. Replace grinding wheel.
    c. Dress grinding wheel.
    d. Grind high-speed steel tool bit.
    e. Grind drill bit.

PEDESTAL GRINDER
UNIT II

SUGGESTED ACTIVITIES

I. Suggested activities for instructor

   A. Provide students with objective sheet.

   B. Provide students with information and assignment sheets.

   C. Discuss unit and specific objectives.

   D. Discuss information and assignment sheets.

   E. Demonstrate and discuss procedures outlined in job sheets.

      (NOTE: Grinding wheels for drill pointers, surface grinders, cylindrical grinders, and tool and cutter grinders will be covered in Volume IV of *Machine Shop* series.)

   F. Make transparencies.

   G. Demonstrate how to use pedestal grinder safely.

   H. Demonstrate how to grind a tool bit.

   I. Demonstrate how to grind a drill bit.

   J. Demonstrate how to dress the wheel.

   K. Demonstrate how to grind carbide tools.

   L. Have students practice Job Sheet #4 using key stock before using high-speed steel tool blank. Provide samples of tool bits.

   M. Give safety test and file in student's folder.

   N. Give test.

   O. Reteach and retest if necessary.

II. Instructional materials

   A. Objective sheet

   B. Information sheet

   C. Transparency masters

      1. TM #1--Shape of Standard Lathe Tools

      2. TM #2--Shape of Standard Drill Bit

SUGGESTED ACTIVITIES

D. Assignment sheets

   1. Assignment Sheet #1--Complete Pedestal Grinder Safety Test

   2. Assignment Sheet #2--Interpret Composition of Grinding Wheels

E. Answers to assignment sheets

F. Job sheets

   1. Job Sheet #1--Check New Grinding Wheel for Cracks

   2. Job Sheet #2--Replace Grinding Wheel

   3. Job Sheet #3--Dress Grinding Wheel

   4. Job Sheet #4--Grind High-Speed Steel Tool Bit

   5. Job Sheet #5--Grind Drill Bit

G. Test

H. Answers to test

III. Unit references

A. Kibbe, Richard R.; Neely, John E.; Meyer, Roland O.; and White, Warren T. *Machine Tool Practices.* New York: John Wiley and Sons, 1979.

B. Krar, S.F.; Oswald, J.W.; and St. Amand, J.E. *Technology of Machine Tools.* Toronto: McGraw-Hill Company of Canada Limited, 1969.

C. Oberg, Erik, and Jones, F.D. *Machinery's Handbook.* 21st ed. Brighton, England: Machinery Publishing Co., Ltd, 1979.

PEDESTAL GRINDER
UNIT II

INFORMATION SHEET

I. Terms and definitions

   A. Face of grinding wheel--The outside circumference of a grinding wheel

   B. Glazing--Condition of grinding wheel face where sharp cutting surface has been worn smooth

   C. Loaded--Pores of the grinding wheel have become filled with particles of material being ground

   D. Abrasive--The cutting agent of a grinding wheel

   E. Grain--Size of the abrasive

   F. Grade--The strength of the bonding agent holding the wheel together; allows the wheel to wear

   G. Structure--Number describing the spacing of the abrasive

   H. Bond--Type of material used to hold the wheel together

   I. Trueing--Making wheel circumference true to its center

   J. Dressing--Making new, sharp cutting agents on the face of the wheel by removing worn surface

   K. Ringing--Checking grinding wheel for cracks

   L. Burn--Tool is too hot and will lose its temper

   M. Arbor--A shaft or spindle used to hold a revolving cutting tool or work to be cut

   N. Honing--Removing the wire edge with a fine abrasive stone after a tool has been ground

II. Rules that apply to safe use of the pedestal grinder (Assignment Sheet #1)

   A. Starting--Stand to one side until grinding wheel has reached its maximum rpm

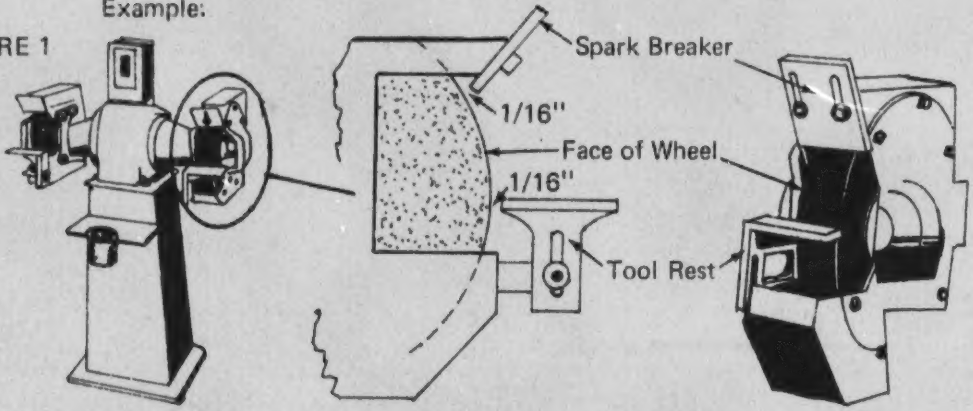
   (NOTE: If the grinding wheel is going to fly apart it will do so when first turned on.)

B. Tool rest and spark breaker--Should be set a maximum of 1/16" from face of grinding wheel (Figure 1)

(NOTE: Too much clearance may cause wheel to pull work down between wheel and tool rest, jamming the wheel.)

Example:

FIGURE 1



C. Adjustments--Never set tool rest or spark breaker while wheel is turning

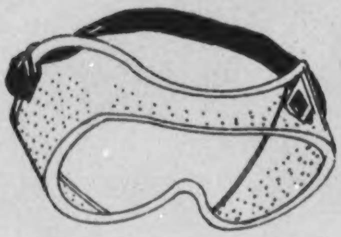
D. Gloves--Never wear gloves when operating the pedestal grinder

(NOTE: Most tools that you are grinding are small; gloves can be easily grabbed by the stone and pulled in, causing fingers to be injured.)

E. Eyes--Wear a face shield or goggles over your safety glasses when using the grinder (Figures 2 and 3)

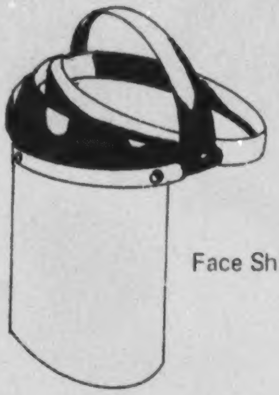
Examples:

FIGURE 2



Goggles

FIGURE 3



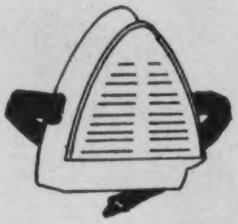
Face Shield

INFORMATION SHEET

F. Respirator--Should be worn for protection during prolonged use of pedestal grinder (Figure 4)

Example:

FIGURE 4



G. Excessive vibration--Stop grinder by turning off power; move to side out of line of grinding wheel until wheel has stopped

(NOTE: This may be a danger signal that the wheel is loose on the spindle or out of balance due to a nick; the wheel could explode.)

H. Face of grinding wheel--Must be flat and free of grooves or rounded edges (Figures 5 and 6)

Examples:

FIGURE 5

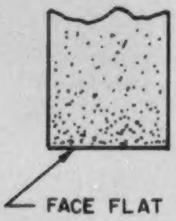
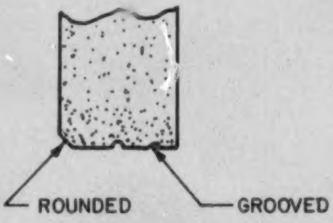


FIGURE 6



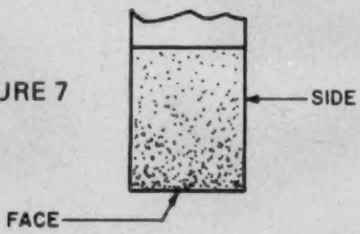
I. Pressure--Work should be fed slowly and gradually into the wheel; never shove it in

(NOTE: Too much pressure will cause excessive heat in the part; if the work slips off the wheel you could jam your hand into the wheel, causing an injury.)

J. Side of wheel--Never grind on the side of the wheel; the strength of the wheel is inward from face to center (Figure 7)

Example:

FIGURE 7



INFORMATION SHEET

K. Non-ferrous materials--Brass, aluminum, copper, wood, plastic and other such materials should never be ground on a pedestal grinder

(NOTE: Materials in the non-ferrous class will load the pores of the wheel, causing it to be ineffective for grinding.)

L. Glazing--Caused by sharp point of the abrasive becoming dull and requiring more pressure to cut

(NOTE: This will cause excessive heat to be transmitted to the part.)

M. Glazed or loaded wheel--Wheel needs to be clean and sharp to be an effective cutting tool

N. Electrical switches--Never try to repair electrical switches; if the grinder does not work, notify your instructor

O. Heat--The tool or part you have been grinding is hot; do not touch it or you will be burned

(NOTE: The tool bit will reach 400° without changing color to indicate heat.)

P. Guards--Never operate a grinder with guards removed

Q. Horseplay--Can cause you or a friend to lose fingers or be seriously hurt; never play around machinery

III. Grinding wheels for different materials

(NOTE: Grinding wheels in this unit are those used on bench and pedestal grinders.)

A. To grind a lathe tool or sharpen a tool made of high-speed steel

1. Rough grind with an aluminum oxide coarse wheel

Example: 32A36-H8VBE

2. Finish grind or sharpen with a fine aluminum oxide wheel

Example: 32A60-M8VBE

B. To sharpen a high-speed drill use a fine aluminum oxide wheel

Example: 32A60-H8VBE

C. To grind cast iron

1. Rough grind or coarse grind with a medium hard, coarse grain silicon carbide wheel

Example: 37C20-H8VK

INFORMATION SHEET

2. Finish grind with a medium hard, medium grain silicon carbide wheel

   Example: 37C46-H8VK

D. To grind hardened tool steel use a wheel made of aluminum oxide

E. Carbide tool steel

1. Rough grind with a coarse silicon carbide wheel
2. Sharpen or finish grind with a fine silicon carbide wheel

   Example: 39C60-I8VK

   (NOTE: It is recommended that grinding of carbide be done on a grinder that uses metal-backed grinding wheels and has a protractor that slides in guides on a tilt table.)

IV. Composition of grinding wheels (Assignment Sheet #2)

(NOTE: Different manufacturers use different numbering systems to designate the composition of their grinding wheels.)

A. Type of abrasive--Material in the grinding wheel that acts as the cutting agent; designated with numbers and letters, with the letters identifying the main base: a = alundum or aluminum oxide; c = silicon carbide or crystolon; d = diamond

Example: 32A = Aluminum oxide

B. Grain or grit--Size of the abrasive, expressed as a number from 10 (coarse) to 600 (very fine)

Examples: 32A 16, 32A 36, 32A 80, 32A 400
coarse medium fine very fine

C. Grade--The strength of the bond holding the wheel abrasives together; determines the rate of which the wheel will break down; designated by letters from A (soft) to Z (hard)

Examples: 32A 36-D, 32A 36-J, 32A 36-R
soft medium hard

INFORMATION SHEET

D. Structure--The grain spacing, designated by a number from 1 to 12; the higher the number, the more "open" the structure (Figures 8 and 9)

Examples:

FIGURE 8

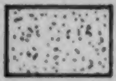
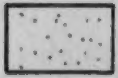
32A36-H6  abrasives are close to each other

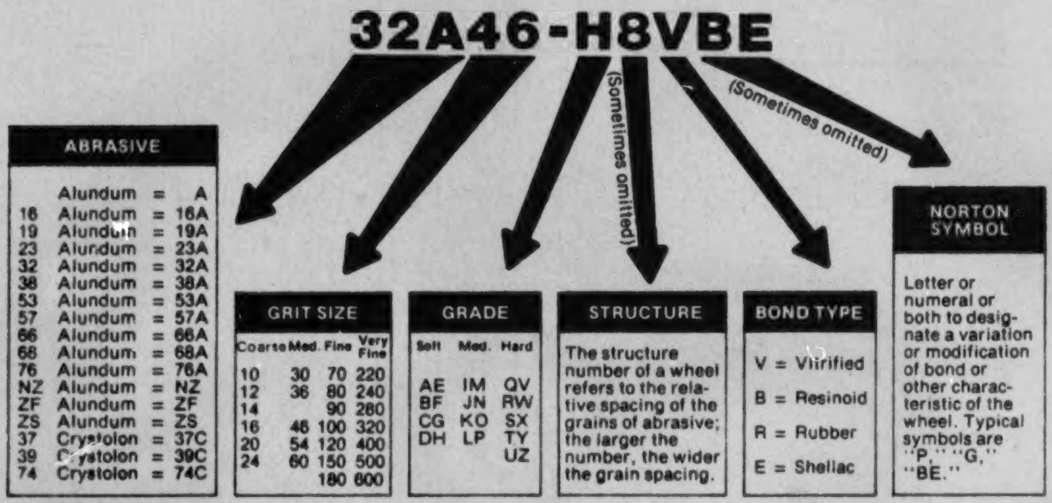
FIGURE 9

32A36-H10  abrasives are farther apart

E. Bond--The material that holds the abrasive together; is designated by a letter or letters (Figure 10)

FIGURE 10

NON-DIAMOND
GRINDING WHEELS



ABRASIVE

Alundum = A
16 Alundum = 16A
19 Alundum = 19A
23 Alundum = 23A
32 Alundum = 32A
38 Alundum = 38A
53 Alundum = 53A
57 Alundum = 57A
66 Alundum = 66A
68 Alundum = 68A
76 Alundum = 76A
NZ Alundum = NZ
ZF Alundum = ZF
ZS Alundum = ZS
37 Crystolon = 37C
39 Crystolon = 39C
74 Crystolon = 74C

GRIT SIZE

Coarse	Med.	Fine	Very Fine
10	30	70	220
12	36	80	240
14		90	280
16	46	100	320
20	54	120	400
24	60	150	500
		180	600

GRADE

Soft	Med.	Hard
AE	IM	QV
BF	JN	RW
CG	KO	SX
DH	LP	TY
		UZ

STRUCTURE

The structure number of a wheel refers to the relative spacing of the grains of abrasive; the larger the number, the wider the grain spacing.

BOND TYPE

V = Vitrified
B = Resinoid
R = Rubber
E = Shellac

NORTON SYMBOL

Letter or numeral or both to designate a variation or modification of bond or other characteristic of the wheel. Typical symbols are "P," "G," "BE."

Used with permission of Norton Company.

INFORMATION SHEET

V. Care and storage of grinding wheels

A. Trueing--New wheels mounted for the first time need to be trued, making the center concentric to the circumference

B. Dressing--A grinding wheel is dressed to improve or alter its cutting action. Dressing removes dull abrasive grains and any foreign material that the wheel may have picked up and exposes sharp new abrasive grains

C. Paper washers or blotters--Used to compensate for any unevenness in the thickness of the grinding wheel and must always be used

D. Tightening--Never overtighten the nut that holds the wheel because you can crack the wheel

E. Ringing--Checking the wheel for cracks; if a wheel is cracked it will not ring clear

(NOTE: This is done when putting on a new wheel or when a wheel has been damaged.)

F. Storing thin wheels--It is recommended that all thin wheels be stored flat with cardboard between each and in a cool place (60-80°F)

G. Balancing large wheels--Wheels 10" or larger must be balanced on the spindle or hub before mounting

H. Starting large wheels--Start and stop large wheels several times to allow the wheels to gain speed slowly

I. Speed--Never turn a grinding wheel faster than the speed marked on the wheel

VI. Grinding problems, possible causes, and corrections

PROBLEM	POSSIBLE CAUSES	SUGGESTED CORRECTION
1. Burning of workpiece	Not enough pressure Wheel too hard Wheel face loaded	Increase amount of pressure or reduce contact area Use softer grade and/or coarser grit wheel Dress to open wheel face
2. Wheel slows or stalls	Pressure too high Belt slippage Wheel too hard	Reduce pressure or reduce contact area Adjust and retighten belts Use softer grade and/or coarser grit wheel
3. Wheel corner breakdown	Wheel too coarse Worn spindle Wheel too soft	Use finer grit wheel Check spindle run out and correct Use harder grade wheel

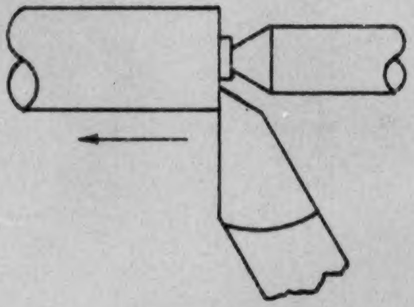
INFORMATION SHEET

VII. Pedestal grinder operations (Transparencies #1 and #2)

A. Grind lathe or sharpen tool to shape (Figure 11)

Example:

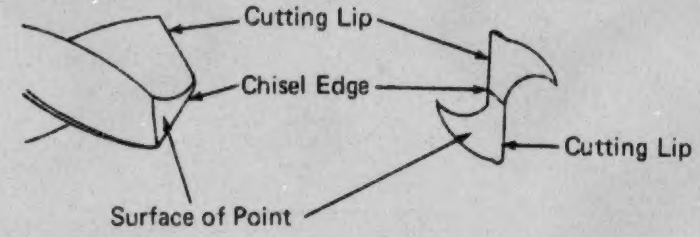
FIGURE 11



B. Sharpen drills (Figure 12)

Example:

FIGURE 12

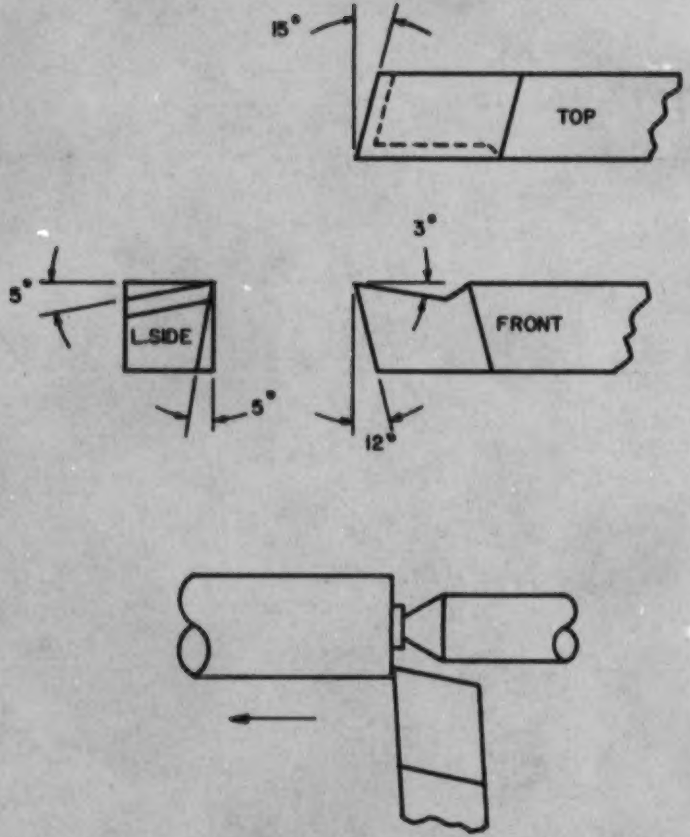

Cutting Lip
Chisel Edge
Cutting Lip
Surface of Point

C. Grind parts to shape

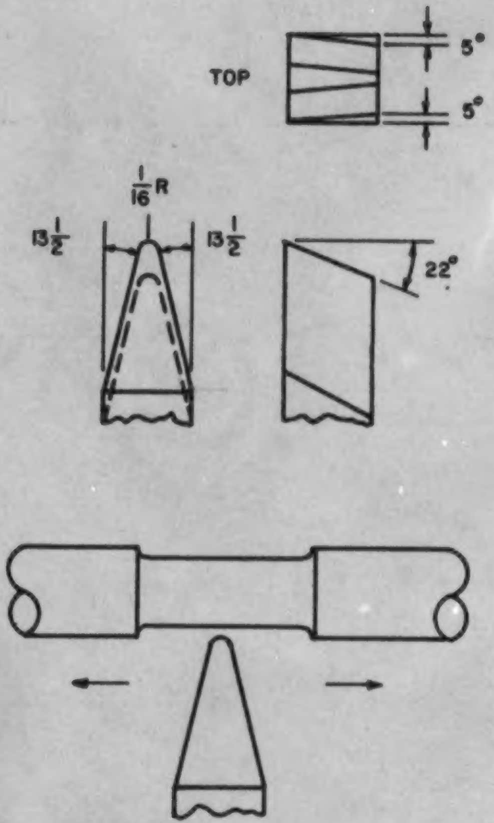
D. Deburr parts

E. Clean up welds

Shape of Standard Lathe Tools

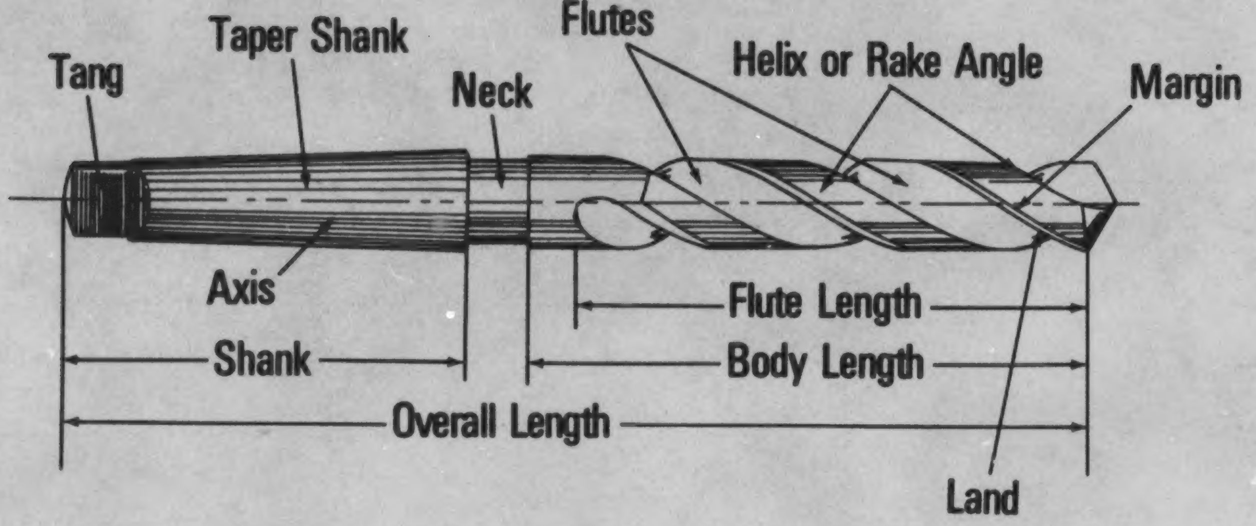

15°
TOP
3°
5°
L.SIDE
FRONT
5°
12°

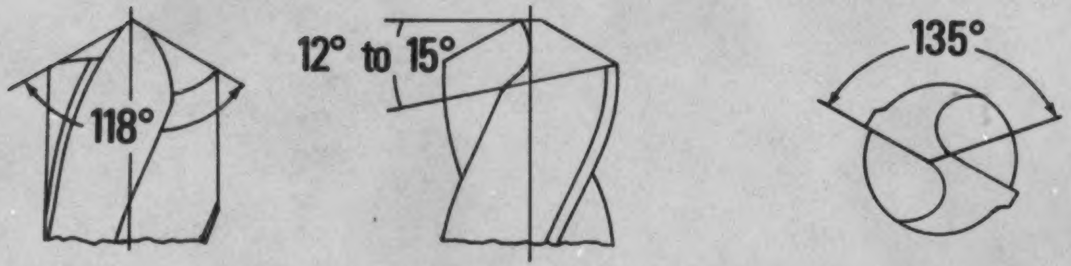
R.H. TURNING TOOL


TOP
5°
5°
$\frac{1}{16}$ R
$13\frac{1}{2}$
$13\frac{1}{2}$
22°

ROUND NOSE TOOL

Shape of Standard Drill Bit


Tang
Taper Shank
Neck
Flutes
Helix or Rake Angle
Margin
Axis
Flute Length
Body Length
Shank
Overall Length
Land


118°
12° to 15°
135°

587

586

General Class of Work

TM 2

MS I - 103-C

PEDESTAL GRINDER
UNIT II

ASSIGNMENT SHEET #1--COMPLETE PEDESTAL GRINDER SAFETY TEST

NAME ______________________ SCORE ______________

(NOTE: The student must complete this safety test with 100 percent accuracy.)

The pedestal grinder is a machine that is used by machinists daily. It looks harmless but isn't; safe use is possible only if proper respect is given to possible hazards that are present.

Complete each of the following rules as they apply to the key words.

1. Adjustments-- ______________________________
2. Eyes-- ______________________________
3. Starting-- ______________________________
4. Gloves-- ______________________________
5. Tool rest and spark breaker-- ______________________________
6. Face of grinding wheel-- ______________________________
7. Respirator-- ______________________________

ASSIGNMENT SHEET #1

8. Pressure-- ____________________

9. Excessive vibration-- ____________________

10. Electrical switches-- ____________________

11. Side of wheel-- ____________________

12. Horseplay-- ____________________

13. Non-ferrous materials-- ____________________

14. Guards-- ____________________

15. Glazing-- ____________________

ASSIGNMENT SHEET #1

16. Heat-- ______________________________

____

____

17. Glazed or loaded wheel-- ______________________________

____

____

PEDESTAL GRINDER
UNIT II

ASSIGNMENT SHEET #2--INTERPRET COMPOSITION OF GRINDING WHEELS

NAME____________________ SCORE__________

Using the proper grinding wheel will make the job faster and better.

Write the meaning of each of the following components of the grinding wheel.

A. 1. Type of abrasive--____________________

____

2. Grain-- ____________________

____

3. Grade-- ____________________

____

4. Structure-- ____________________

____

5. Bond-- ____________________

____

B. Interpret the composition of each of the following wheels from the manufacturers' numbers.

1) 32A24-06VBE

Type of abrasive--____________________

Grain-- ____________________

Grade-- ____________________

Structure-- ____________________

Bond-- ____________________

ASSIGNMENT SHEET #2

2) 32A80-I10VBE

Type of abrasive--____________________

Grain-- ____________________

Grade-- ____________________

Structure-- ____________________

Bond-- ____________________

PEDESTAL GRINDER
UNIT II

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

1. Never set tool rest or spark breaker while wheel is turning
2. Wear a face shield or goggles over your safety glasses when using the grinder
3. Stand to one side until grinding wheel has reached its maximum rpm
4. Never wear gloves when operating the pedestal grinder
5. Should be set a maximum of 1/16" from face of grinding wheel
6. Must be flat and free of grooves or rounded edges
7. Should be worn for protection during prolonged use of pedestal grinder
8. Work should be fed slowly and gradually into the wheel; never shove it in
9. Stop grinder by turning off power; move to side out of line of grinding wheel until wheel has stopped
10. Never try to repair electrical switches; if the grinder does not work, notify your instructor
11. Never grind on the side of the wheel; the strength of the wheel is inward from face to center
12. Can cause you or a friend to lose fingers or be seriously hurt; never play around machinery
13. Brass, aluminum, copper, wood, plastic and other such materials should never be ground on a pedestal grinder
14. Never operate a grinder with guards removed
15. Caused by sharp point of the abrasive becoming dull and requiring more pressure to cut
16. The tool or part you have been grinding is hot; do not touch it or you will be burned
17. Wheel needs to be clean and sharp to be an effective cutting tool

Assignment Sheet #2

A. 1. Material in the grinding wheel that acts as the cutting agent; designated with numbers and letters, with the letters identifying the main base

2. Size of the abrasive, expressed as a number from 10 (coarse) to 600 (very fine)

3. The strength of the bond holding the wheel abrasives together; determines the rate at which the wheel will break down; designated by letters from A (soft) to Z (hard)

4. The grain spacing, designated by a number from 1 to 12; the higher the number, the more "open" the structure

5. The material that holds the abrasive together; is designated by a letter or letters

B. 1) Abrasive is alundum or aluminum oxide

Grain size is coarse (24)

Grade is medium (0)

Structure is medium (6)

Bond is vitrified, resinoid, shellac

2) Abrasive is alundum or aluminum oxide

Grain size is fine (80)

Grade is medium (I)

Structure is wide spacing (10)

Bond is vitrified, resinoid, shellac

PEDESTAL GRINDER
UNIT II

JOB SHEET #1--CHECK NEW GRINDING WHEEL FOR CRACKS

I. Tools and equipment

A. 1/2" wooden dowel 6" long

B. Plastic handled screwdriver

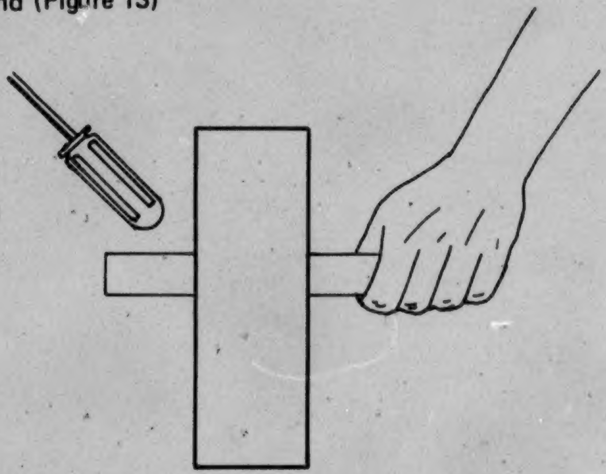
C. 6" or 8" grinding wheel

II. Procedure

A. Check to make sure wheel is dry and free of sawdust before testing; otherwise sound may be deadened

B. Place the dowel through the center hole of the wheel and hold it with one hand (Figure 13)

FIGURE 13



(NOTE: Large wheels require assistance.)

C. Grasp the blade of the screwdriver in the other hand

D. Tap the wheel lightly with the screwdriver handle and listen for a ring; a cracked wheel will not ring clear

(NOTE: Vitrified or silicate wheels will have a clear metallic ring. Organic bonded wheels have a duller ring.)

PEDESTAL GRINDER
UNIT II

JOB SHEET #2--REPLACE GRINDING WHEEL

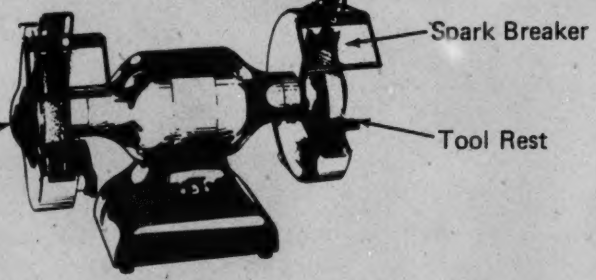
I. Tools and equipment

- A. New grinding wheel of correct size and composition
- B. Wrench to fit spindle nut
- C. Wrenches to fit tool rest and spark breaker
- D. Piece of wood 3/4" x 2" x 12" (oak preferred)
- E. Screwdriver (standard point)
- F. Wire brush

II. Procedure

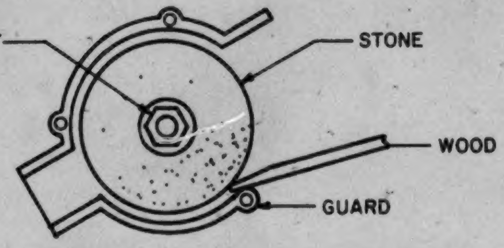
- A. Remove the side cover by removing the screws on the side, and adjusting the tool rest and spark breaker out (Figure 14)

FIGURE 14


Spark Breaker
Side Cover
Tool Rest

- B. Insert the piece of wood between the wheel and wheel guard to hold the wheel so you can loosen the spindle nut (Figure 15)

FIGURE 15


SPINDLE NUT
STONE
WOOD
GUARD

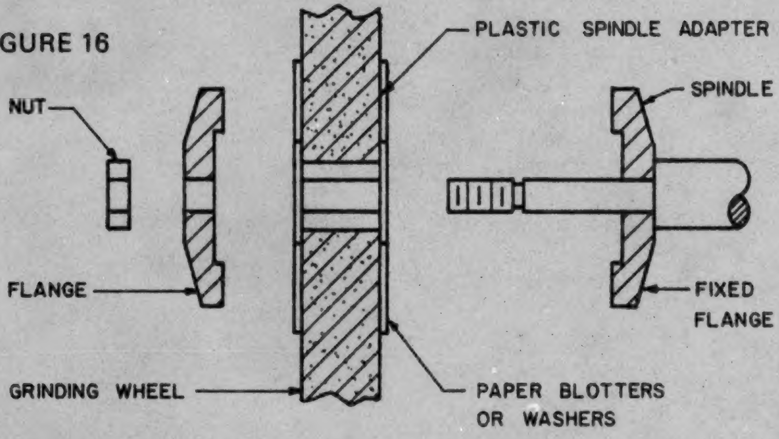
JOB SHEET #2

C. Loosen the spindle nut

D. Remove the flange

E. Slide the wheel off the spindle (Figure 16)

FIGURE 16



F. Remove the plastic spindle adapter

(NOTE: The grinding wheel may or may not have a plastic adapter. The need for the adapter depends on the manufactured hole size of the grinding wheel.)

G. Clean out guard with wire brush and wipe off spindle and fixed flange with a clean rag

H. Put new grinding wheel that you have already tested for cracks on the spindle

(NOTE: If grinding wheel does not have paper washers on each side of wheel, you will need to acquire these before mounting the grinding wheel.)

I. Replace flange and secure with nut

J. Use board to hold wheel and tighten nut

(CAUTION: Do not overtighten as you can crack the grinding wheel. Tighten it enough to keep it from slipping.)

K. Replace the side cover

L. Adjust the tool rest and spark breaker, rotating the wheel by hand to make sure it is not out-of-round so much it will hit the tool rest or spark breaker

M. Tighten the tool rest and turn on the power to check the wheel

(NOTE: The new grinding wheel needs to be trued before it is used.)

PEDESTAL GRINDER
UNIT II

JOB SHEET #3--DRESS GRINDING WHEEL

I. Tools and equipment

A. Pedestal grinder

B. Desmond Huntington dresser of the correct size for the wheel you are dressing

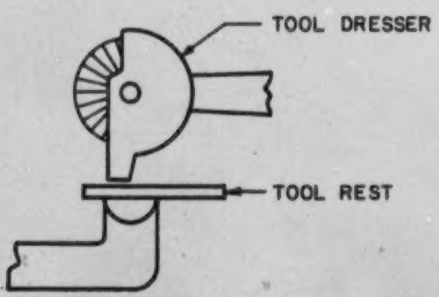
(NOTE: Wheel diameters 3" to 10" should be dressed with a number zero [#O] dresser.)

C. Face shield or goggles

II. Procedure

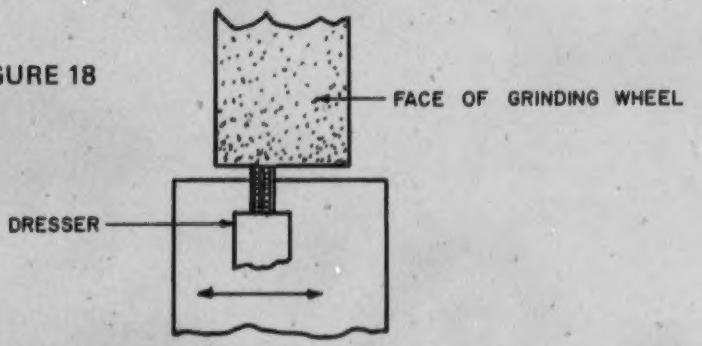
A. Set the bottom pads of the dresser on the tool rest (Figure 17)

FIGURE 17



B. Slide the dresser into the grinding wheel until there are no sparks; then move the dresser across the face of the grinding wheel (Figure 18)

FIGURE 18



C. Continue this procedure until the wheel has a smooth, sharp, flat face

PEDESTAL GRINDER
UNIT II

JOB SHEET #4--GRIND HIGH-SPEED STEEL TOOL BIT

I. Tools and equipment

- A. Pedestal grinder with water tray

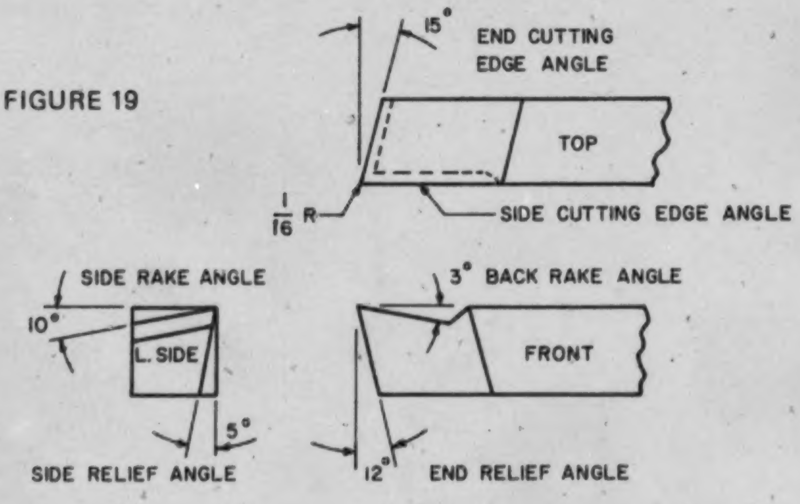
  (NOTE: If grinder has no water tray, place container of water near grinder.)

- B. One high-speed steel tool blank
- C. Goggles or face shield
- D. Tool dresser
- E. Sample tool bit
- F. 2 pieces of 3/8" square key stock

II. Procedure

- A. Develop a mental picture of what the finished tool will look like (Figure 19)

FIGURE 19


15°
END CUTTING EDGE ANGLE
TOP
1/16 R
SIDE CUTTING EDGE ANGLE
SIDE RAKE ANGLE
10°
L. SIDE
5°
SIDE RELIEF ANGLE
3° BACK RAKE ANGLE
FRONT
12°
END RELIEF ANGLE

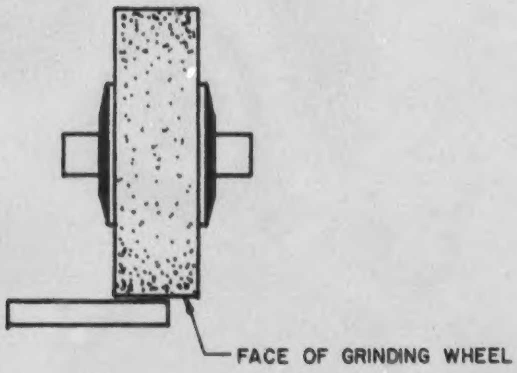
  (NOTE: Depending on the type of tool holder, the end relief angle will vary.)

- B. Hold the tool bit firmly while supporting hands on the tool rest

JOB SHEET #4

C. Turn the tool so the side is parallel to the face of the wheel (Figure 20)

FIGURE 20

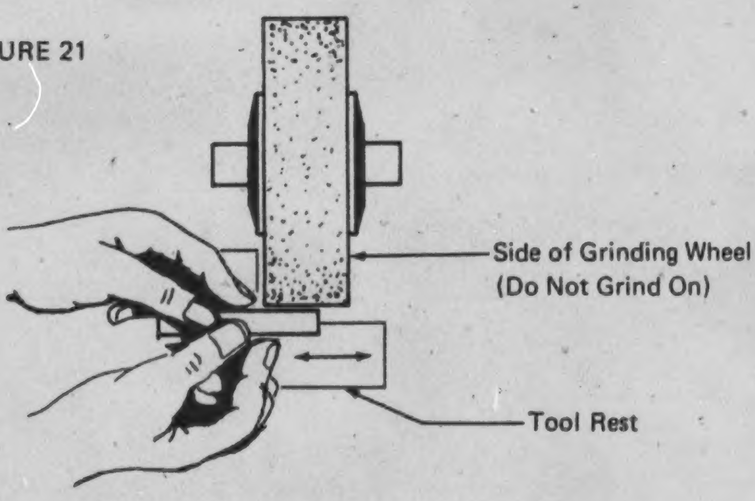

FACE OF GRINDING WHEEL

D. Tilt the bottom of the tool bit toward the wheel at 5° for the side clearance angle

E. Move the work in contact with the face of the wheel

(NOTE: Do not hold the tool in one spot; move it sideways to keep the face of the wheel flat. See Figure 21.)

FIGURE 21


Side of Grinding Wheel
(Do Not Grind On)
Tool Rest

(CAUTION: Do not apply too much pressure; if the tool slips off the wheel you could run your finger into the wheel, causing an injury.)

JOB SHEET #4

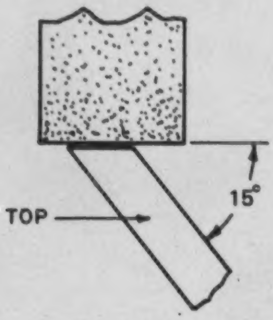
F. Cool the tool frequently during grinding by quenching in water tray

(NOTE: Carbide tools should never be quenched.)

G. Grind the cutting edge and end relief angles at the same time

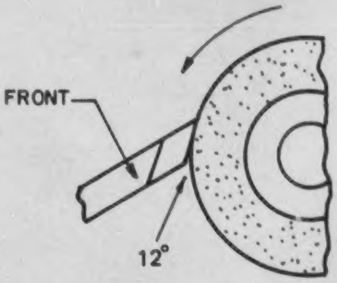
H. Turn the tool so end is at 15° angle and tilt the tool back 12° for front clearance (Figures 22 and 23)

FIGURE 22



END CUTTING EDGE ANGLE

FIGURE 23



END RELIEF ANGLE

I. Hold the tool at approximately 45° to the axis of the wheel and grind the side rake angle to approximately 10° (Figures 24 and 25)

FIGURE 24

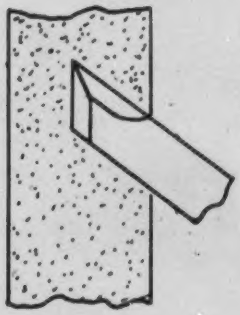
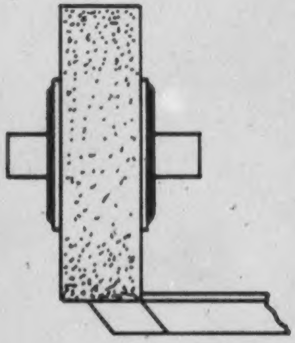


FIGURE 25



JOB SHEET #4

J. Grind a slight radius on the point of the cutting tool, maintaining the same clearances with the radius and front and side clearance angles (Figures 26 and 27)

FIGURE 26

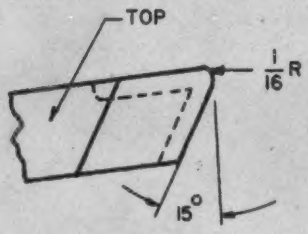
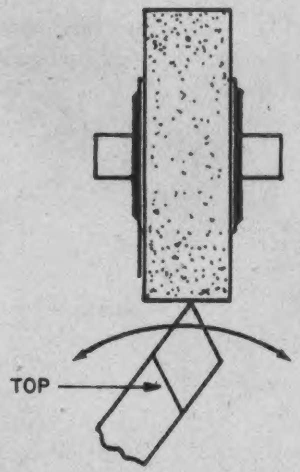
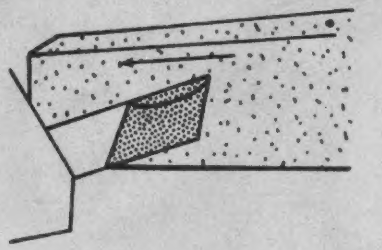


FIGURE 27



K. Hone the cutting edge of the tool bit (Figure 28)

FIGURE 28



L. Dress the wheel to expose sharp, new cutting particles

M. Clean the area of grinding dust when you are through with the grinder

(NOTE: Carbide may be ground on a pedestal grinder if you put on a silicon carbide grinding wheel. Never grind carbide on an aluminum oxide wheel.)

PEDESTAL GRINDER
UNIT II

JOB SHEET #5--GRIND DRILL BIT

I. Tools and equipment

   A. Drill point gage

   B. Drill to sharpen (size 3/8" to 3/4")

   C. Pedestal grinder

   D. Face shield or goggles

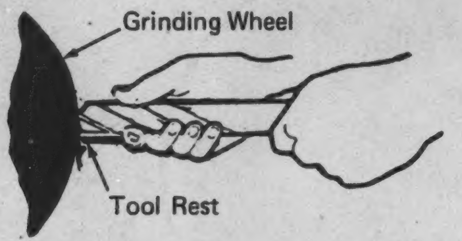
   E. Grinding wheel dresser

II. Procedure

   A. Dress the grinding wheel

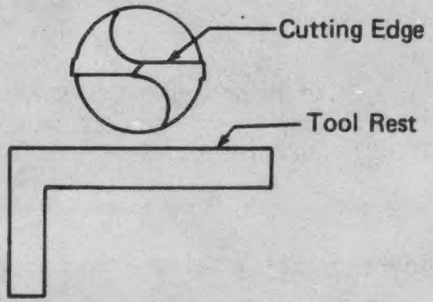
   B. Hold the drill near the point with one hand, and put the other hand on the shank (Figure 29)

FIGURE 29


Grinding Wheel
Tool Rest

   C. Hold the lip on cutting edge of the drill parallel to the tool rest (Figure 30)

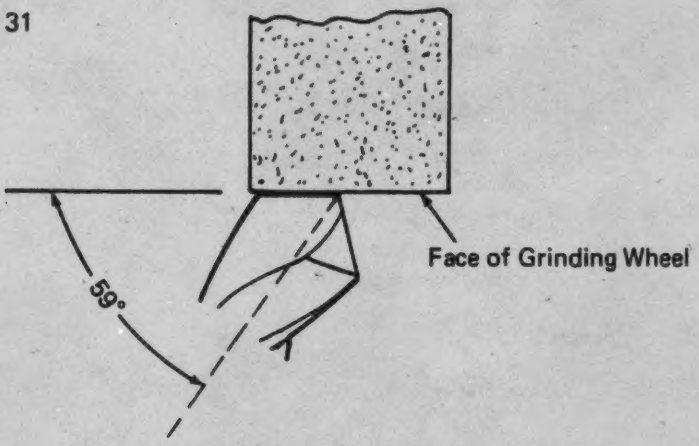
FIGURE 30


Cutting Edge
Tool Rest

JOB SHEET #5

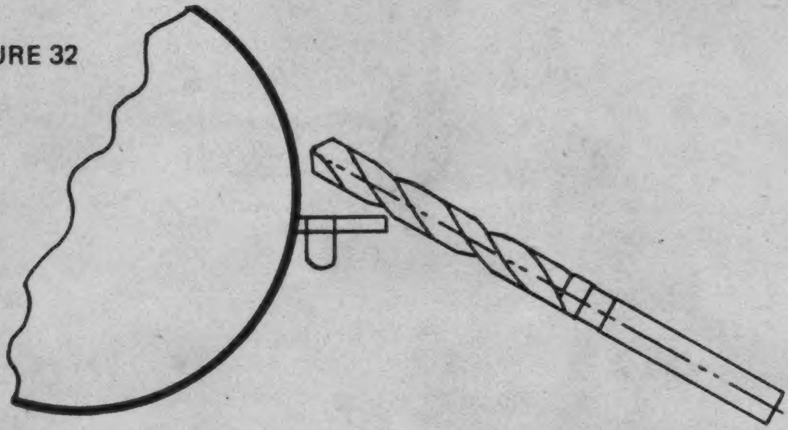
D. Turn the drill until it is approximately 59° to the face of the grinding wheel (Figure 31)

FIGURE 31



E. Hold the drill so the point is higher than the shank (Figure 32)

FIGURE 32



F. Bring the lip of the drill against the wheel and lower the shank

(NOTE: Do not twist the drill.)

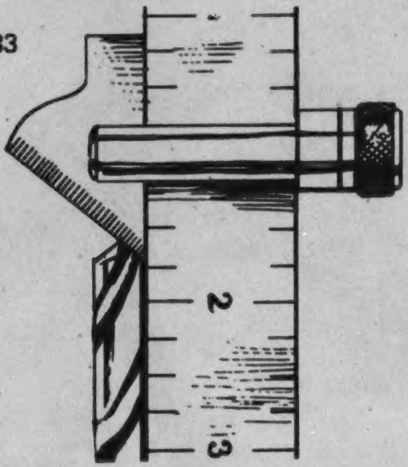
G. Pull the drill away from the wheel and rotate the drill one-half turn

H. Grind the other lip in the same manner as above

JOB SHEET #5

I. Check the angle and cutting lip length by using a drill point gage (Figure 33)

FIGURE 33

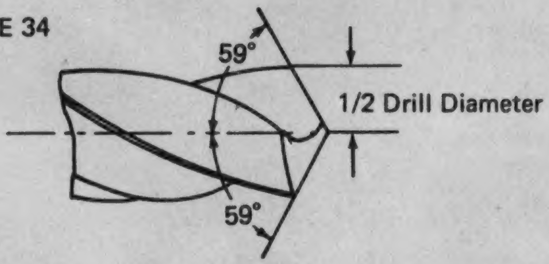


J. Repeat operations D through I until the angles are correct

K. When the drill is ground correctly, all these conditions will be present

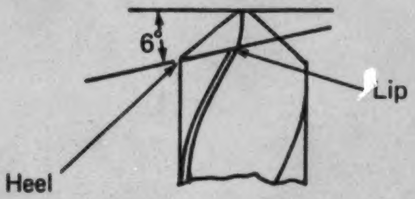
1. The drill will have a 59° angle per side or a 118° included angle (Figure 34)

FIGURE 34



2. The drill will have a heel clearance angle of 6° to 9° (Figure 35)

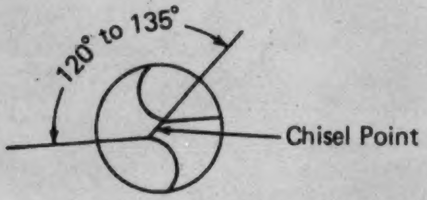
FIGURE 35



JOB SHEET #5

3. The angle of the lip to the chisel point will be from 120° to 135° depending on the heel clearance angle (Figure 36)

FIGURE 36



L. Clean up your area, put tools in proper place, and take drill to your instructor for evaluation

(NOTE: If a drill bit is not ground properly, it will not drill a hole of the correct size, or it may not drill a hole at all. Soon the bit will be ruined because too much pressure will be needed to operate it.)

MS I - 127-C

PEDESTAL GRINDER
UNIT II

TEST

NAME____ SCORE______________

1. Match terms associated with the pedestal grinder and hand grinding to the correct definitions. Write the correct numbers in the blanks.

_____a. The outside circumference of a grinding wheel

_____b. Tool is too hot and will lose its temper

_____c. Condition of grinding wheel face where sharp cutting surface has been worn smooth

_____d. Checking grinding wheel for cracks

_____e. Making new, sharp cutting agents on the face of the wheel by removing worn surface

_____f. The cutting agent of a grinding wheel

_____g. Pores of the grinding wheel have become filled with particles of material being ground

_____h. Making wheel circumference true to its center

_____i. Size of the abrasive

_____j. The strength of the bonding agent holding the wheel together; allows the wheel to wear

_____k. Type of material used to hold the wheel together

_____l. Number describing the spacing of the abrasive

_____m. A shaft or spindle used to hold a revolving cutting tool or work to be cut

_____n. Removing the wire edge with a fine abrasive stone after a tool has been ground

1. Grade
2. Structure
3. Loaded
4. Ringing
5. Glazing
6. Trueing
7. Honing
8. Face of grinding wheel
9. Abrasive
10. Grain
11. Burn
12. Arbor
13. Bond
14. Dressing

2. State rules that apply to safe use of the pedestal grinder.

a. Starting-- ______________________________

b. Tool rest and spark breaker-- ______________________________

c. Eyes-- ______________________________

d. Pressure-- ______________________________

e. Non-ferrous materials-- ______________________________

f. Adjustments-- ______________________________

g. Gloves-- ______________________________

h. Respirator-- ______________________________

i. Excessive vibration-- ______________________________

j. Face of grinding wheel-- ______________________________

k. Side of wheel-- ______________________________

l. Glazing-- ______________________________

m. Glazed or loaded wheel-- ______________________________

n. Electrical switches-- ______________________________

____

o. Heat-- ______________________________

____

p. Guards-- ______________________________

____

q. Horseplay-- ______________________________

____

3. Select the proper grinding wheel for different materials. Write the correct numbers in the blanks.

_____a. To rough grind a high-speed steel lathe tool

_____b. To rough grind a cast iron part

_____c. To finish grind a part made of hardened tool steel

_____d. To finish grind a high-speed steel lathe tool

_____e. To sharpen a tool made of high-speed steel

_____f. To rough grind a carbide tool bit

_____g. To finish grind a part made of cast iron

_____h. To sharpen a carbide tool

1. Coarse aluminum oxide
2. Coarse silicon carbide
3. Fine aluminum oxide
4. Fine silicon carbide
5. Medium silicon carbide

4. Interpret the composition of grinding wheels by writing the meanings of the wheel markings listed. Use the grinding wheel chart shown below.

Alundum = A 16 Alundum = 16A 19 Alundum = 19A 23 Alundum = 23A 32 Alundum = 32A 38 Alundum = 38A 53 Alundum = 53A 57 Alundum = 57A 75 Alundum = 75A NZ Alundum = NZ ZF Alundum = ZF ZS Alundum = ZS 37 Crystolon = 37C 39 Crystolon = 39C CBN = CB	Coarse Medium 10 30 12 36 14 16 46 20 54 24 60 Very Fine Fine 70 220 80 240 90 280 100 320 120 400 150 500 180 600	Soft A Thru H Medium I Thru P Hard Q Thru Z	The structure number of a wheel refers to the relative spacing of the grains of abrasive; the larger the number, the wider the grain spacing.	V = Vitrified B = Resinoid R = Rubber E = Shellac	Letter or numeral or both to designate a variation or modification of bond or other characteristic of the wheel. Typical symbols are "P," "G," "BE."

Used with permission of Norton Company.

a. 32A36-P8VBE--

Abrasive--

Grain size--

Grade--

Structure--

Bond--

b. 39C60-H5V--

Abrasive--

Grain size--

Grade--

Structure--

Bond--

5. Describe care and storage of grinding wheels in the spaces below.

a. Dressing--

b. Storing thin wheels-- ______________________________

____

____

c. Speed-- ____________________________________

____

____

d. Paper washers or blotters-- ___________________________

____

____

e. Starting large wheels-- _____________________________

____

____

f. Trueing-- ___________________________________

____

____

g. Tightening-- _________________________________

____

____

h. Balancing large wheels-- ____________________________

____

____

i. Ringing-- ___________________________________

____

____

6. Match grinding problems to their possible causes and corrections. Write the correct numbers in the blanks. Some blanks may have more than one answer.

   1. Burning of workpiece
   2. Wheel slows or stalls
   3. Wheel corner breakdown

_____a. Cause--Wheel too hard
Correction--Use softer grade and/or coarser grit wheel

_____b. Cause--Not enough pressure
Correction--Increase amount of pressure or reduce contact area

_____c. Cause--Wheel too soft
Correction--Use harder grade wheel

d. Cause--Pressure too high
Correction--Reduce pressure or reduce contact area

_____e. Cause--Wheel too coarse
Correction--Use finer grit wheel

_____f. Cause--Wheel face loaded
Correction--Dress to open wheel face

_____g. Cause--Belt slippage
Correction--Adjust and retighten belts

_____h. Cause--Worn spindle
Correction--Check spindle run out and correct

7. Name five jobs that are pedestal grinder operations.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

8. Demonstrate the ability to:

a. Check new grinding wheel for cracks.

b. Replace grinding wheel.

c. Dress grinding wheel.

d. Grind high-speed steel tool bit.

e. Grind drill bit.

(NOTE: If the above activities have not been finished before the test, ask your instructor when they should be completed.)

PEDESTAL GRINDER
UNIT II

ANSWERS TO TEST

(NOTE: The point system designated in parentheses is intended to be a guideline and should be adapted as needed. The point total is 250.)

1. (28 points)

   a. 8
   b. 11
   c. 5
   d. 4
   e. 14
   f. 9
   g. 3
   h. 6
   i. 10
   j. 1
   k. 13
   l. 2
   m. 12
   n. 7

2. (51 points)

   a. Starting--Stand to one side until grinding wheel has reached its maximum rpm

   b. Tool rest and spark breaker--Should be set a maximum of 1/16" from face of grinding wheel

   c. Eyes--Wear a face shield or goggles over your safety glasses when using the grinder

   d. Pressure--Work should be fed slowly and gradually into the wheel; never shove it in

   e. Non-ferrous materials--Brass, aluminum, copper, wood, plastic, and other such materials should never be ground on a pedestal grinder

   f. Adjustments--Never set tool rest or spark breaker while wheel is turning

   g. Gloves--Never wear gloves when operating the pedestal grinder

   h. Respirator--Should be worn for protection during prolonged use of pedestal grinder

   i. Excessive vibration--Stop grinder by turning off power; move to side out of line of grinding wheel until wheel has stopped

   j. Face of grinding wheel--Must be flat and free of grooves or rounded edges

   k. Side of wheel--Never grind on the side of the wheel; the strength of the wheel is inward from face to center

l. Glazing--Caused by sharp point of the abrasive becoming dull and requiring more pressure to cut

m. Glazed or loaded wheel--Wheel needs to be clean and sharp to be an effective cutting tool

n. Electrical switches--Never try to repair electrical switches; if the grinder does not work, notify your instructor

o. Heat--The tool or part you have been grinding is hot; do not touch it or you will be burned

p. Guards--Never operate a grinder with guards removed

q. Horseplay--Can cause you or a friend to lose fingers or be seriously hurt; never play around machinery

3. (16 points)

a. 1

b. 2

c. 3

d. 3

e. 3

f. 2

g. 5

h. 4

4. (12 points)

a. 32A is an alundum or aluminum oxide abrasive with a medium grain size of 36, medium grade, fairly open structure, vitrified, resinoid, and shellac bond

b. 39C is a crystolon or silicon carbide abrasive with a medium grain size of 60, soft grade, fairly closed structure, vitrified bond

5. (27 points)

a. Dressing--A grinding wheel is dressed to improve or alter its cutting action. Dressing removes dull abrasive grains and any foreign material that the wheel may have picked up and exposes sharp new abrasive grains

b. Storing thin wheels--It is recommended that all thin wheels be stored flat with cardboard between each and in a cool place (60-80°F)

c. Speed--Never turn a grinding wheel faster than the speed marked on the wheel

d. Paper washers or blotters--Used to compensate for any unevenness in the thickness of the grinding wheel and must aways be used

e. Starting large wheels--Start and stop large wheels several times to allow the wheel to gain speed slowly

f. Trueing--New wheels mounted for the first time need to be trued, making the center concentric to the circumference

g. Tightening--Never overtighten the nut that holds the wheel because you can crack the wheel

h. Balancing large wheels--Wheels 10" or larger must be balanced on the spindle or hub before mounting

i. Ringing--Checking the wheel for cracks; if a wheel is cracked it will not ring clear

6. (16 points)

a. 1 or 2

b. 1

c. 3

d. 2

e. 3

f. 1

g. 2

h. 3

7. (5 points)

a. Grind lathe or sharpen tool to shape

b. Sharpen drills

c. Grind parts to shape

d. Deburr parts

e. Clean up welds

8. (95 points)

Performance skills evaluated to satisfaction of instructor

Job Sheets #1-3, 15 points each

Job Sheets #4-5, 25 points each

POWER SAWS
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to use power saws correctly and safely. The student should be able to set the correct band speeds, select the proper type of blade, and perform general maintenance on power saws. This knowledge will be shown by completing assignment sheets, job sheets, and unit test with a minimum score of 85 percent accuracy.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with power saws to the correct definitions.
2. Match types of power saws to the correct definitions.
3. Identify major parts of a reciprocating hacksaw.
4. Identify major parts of a horizontal band saw.
5. Identify major parts of a vertical band saw.
6. Identify major parts of the butt welder.
7. Distinguish between operations that can be performed on a horizontal band saw and operations that can be performed on a vertical band saw.
8. Identify types of blade guides.
9. Identify accessories used with power saws.
10. List methods for determining band saw speeds for different materials.
11. Select from a list factors that determine saw blade selection.
12. Select the correct saw blades for different jobs.
13. State rules for safe use of power saws.
14. Describe care and cleaning of power saws.
15. State reasons for welding a band saw blade.
16. Calculate stock lengths.
17. Complete power saw safety test.

18. Demonstrate the ability to:

    a. Weld a band saw blade.

    b. Coil and uncoil a band saw blade.

    c. Cut stock with horizontal band saw.

    d. Cut steel bar stock with vertical band saw.

    e. Cut aluminum plate to layout with vertical band saw.

POWER SAWS
UNIT I

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:
  A. Make transparencies.
  B. Provide students with objective sheet.
  C. Provide students with information and assignment sheets.
  D. Discuss unit and specific objectives.
  E. Discuss information and assignment sheets.
  F. Demonstrate and discuss procedures outlined in job sheets.
  G. Demonstrate direction of teeth on band saws.
  H. Save 5" pieces from Job Sheet #3 for later projects.
  I. Give test.
  J. Reteach and retest if necessary.

II. Instructional materials:
  A. Objective sheet
  B. Information sheet
  C. Transparency masters
    1. TM 1--Major Parts of the Reciprocating Hacksaw
    2. TM 2--Major Parts of the Horizontal Band Saw
    3. TM 3--Major Parts of the Vertical Band Saw
    4. TM 4--Parts of the Butt Welder
    5. TM 5--Horizontal Saw Operations
    6. TM 6--Vertical Saw Operations
    7. TM 7--Types of Blade Guides
    8. TM 8--Saw Accessories
    9. TM 9--Shape and Cut of Band Saw Blades

D. Assignment sheets

  1. Assignment Sheet #1--Complete Power Saw Safety Test
  2. Assignment Sheet #2--Calculate Stock Lengths
  3. Assignment Sheet #3--Select Saw Blade for Different Jobs

E. Answers to assignment sheets

F. Job sheets

  1. Job Sheet #1--Weld a Band Saw Blade
  2. Job Sheet #2--Coil and Uncoil a Band Saw Blade
  3. Job Sheet #3--Cut Stock with Horizontal Band Saw
  4. Job Sheet #4--Cut Steel Bar Stock with Vertical Band Saw
  5. Job Sheet #5--Cut Aluminum Plate to Layout with Vertical Band Saw

G. Test

H. Answers to test

III. Unit references:

A. Krar S.F.; Oswald, J.S.; and St. Amand, J.D. *Technology of Machine Tools*. Toronto: McGraw-Hill Book Company of Canada, 1969.

B. McCarthy, Willard J. and Smith, Robert E. *Machine Tool Technology*. Bloomington: McKnight and McKnight, 1968.

C. Kribbe, Richard R.; Neely, John E.; Meyer, Roland O.; and White, Warren T. *Machine Tool Practices*. New York: John Wiley and Sons, 1979.

POWER SAWS
UNIT I

INFORMATION SHEET

I. Terms and definitions

A. Kerf--Amount of material consumed each time the saw makes a cut

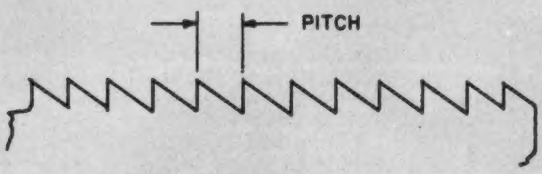
B. Contouring--Cutting a shape that is not straight

C. Friction sawing--Use of speed and heat to saw

D. Fixture--Part made to hold work that will have other work performed on it

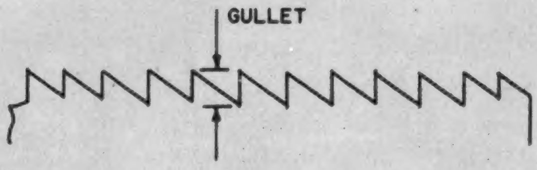
E. Pitch--Distance from one tooth to corresponding point of the next tooth

Example:



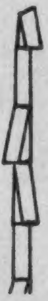
F. Gullet--Space from top of tooth to bottom

Example:



G. Set--The bending of a portion of every other tooth toward one side and the alternate teeth toward the opposite side to allow clearance for the blade thickness

Example:



INFORMATION SHEET

H. Cutting speed--Number of feet of the blade that pass through the work in one minute (sfpm)

I. Circumference--Distance around a round object

J. Coiling--Method of rolling up a saw blade

II. Types of power saws

A. Reciprocating hacksaw--Consists of a base with vise and a frame with saw blade that moves back and forth by means of a cam; is motor driven, with a v-belt and pulley for different speeds

B. Horizontal band saw--Consists of a base with vise and a frame with two wheels that carries a saw blade and adjustable saw guides; is motor driven with v-belts and pulleys for different band speeds

C. Vertical band saw--Consists of a base with table and idler wheels that carry a saw blade with adjustable upper saw guide; is motor driven with speeds obtained by transmission or variable speed pulley

III. Major parts of a reciprocating hacksaw (Transparency 1)

A. Saw frame

B. Blade

C. Blade tensioning nut

D. Vise

E. Base

F. Coolant tray

G. Table

H. Switch

I. Motor

J. Gear shift

K. Connecting rod

L. Crank-disc

M. Coolant valve

IV. Major parts of a horizontal band saw (Transparency 2)

A. Idler wheels

B. Blade tension handle

INFORMATION SHEET

- C. Shields
- D. Table
- E. Vise handwheel
- F. Switch
- G. Base
- H. Band blade
- I. Vise
- J. Coolant tray
- K. Saw guides
- L. Motor and step pulleys
- M. Frame weight
- N. Guide posts
- O. Saw frame

V. Major parts of a vertical band saw (Transparency 3)

- A. Blade tension indicator
- B. Speed indicator
- C. Blade cutter
- D. Switch
- E. Welder
- F. Speed control
- G. Blade tension handle
- H. Power feed foot pedal
- I. Power feed handwheel
- J. Motor cover
- K. Table
- L. Blade guide

INFORMATION SHEET

- M. Guide post
- N. Air jet
- O. Job selector dial

VI. Major parts of the butt welder (Transparency 4)

- A. Grinding wheel guard
- B. Grinding wheel
- C. Weld selector switch
- D. Blade clamps
- E. Welding switch lever
- F. Annealing button
- G. Etching clamp
- H. Blade thickness gage

VII. Operations performed on horizontal band saw and vertical band saw

- A. Horizontal saw (Transparency 5)
    1. Square cutting
    2. Angular cutting
    3. Stack cutting
- B. Vertical band saw (Transparency 6)
    1. Contouring
    2. Filing
    3. Friction sawing
    4. Fixture work
    5. Square cutting
    6. Angular cutting

VIII. Types of blade guides (Transparency 7)

- A. Friction guide
- B. Roller guide

INFORMATION SHEET

IX. Accessories used with power saws (Transparency 8)

- A. Workpiece fixture
- B. Universal fence
- C. Work support
- D. Workholding jaws with feed chain and cable
- E. Cut-off gage or stop

X. Determining band saw speeds for different materials

- A. Job selector dial on saw
- B. Machinist's handbook

XI. Factors that determine saw blade selection

- A. Material
- B. Thickness of material
- C. Type of job
- D. Width of blade

XII. Selecting the correct saw blade (Transparency 9; Assignment Sheet #3)

- A. Thickness of workpiece
    1. Use a chart that shows material thickness and tooth per inch for most accurate saw blade selection

(NOTE: Charts are displayed on many machines and appear in machinists' handbooks.)

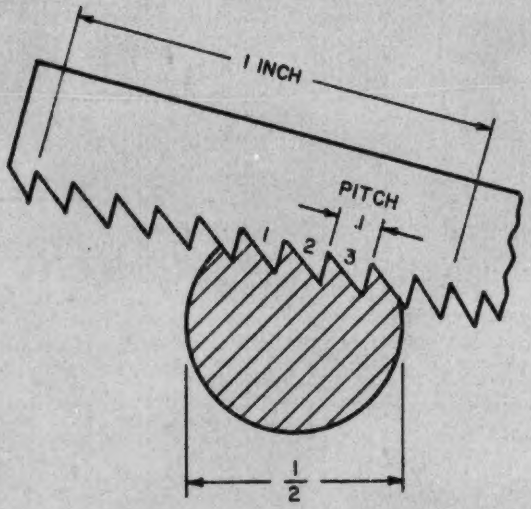
Material Thickness	Tooth Per Inch	Pitch
1/8" to 3/16"	24 teeth	.041
1/4" to 5/16"	18 teeth	.055
3/8" to 7/16"	14 teeth	.071
1/2" to 3/4"	10 teeth	.100
13/16" to 1"	8 teeth	.125
1 1/16" to 3"	6 teeth	.166
over 3"	4 teeth	.250

INFORMATION SHEET

2. Use "three-teeth" rule for a general guideline in saw blade selection; a minimum of three teeth should be in workpiece at all times to prevent too much load or pressure on individual teeth

   (NOTE: Multiply pitch by three to assist in applying the "three-teeth" rule. Too many teeth in workpiece causes gullets to fill with chips, preventing efficient cutting.)

   Example:



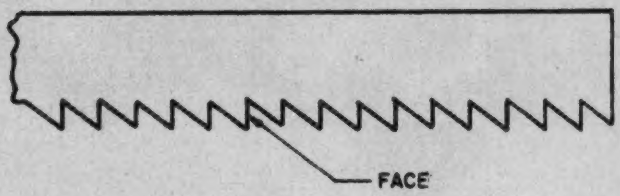
10 TEETH PER INCH OR
1/10 = PITCH = .1

B. Tooth shape

1. Regular or precision tooth--Used on vertical or horizontal band saws; recommended for cutting all ferrous materials such as steel plate, high carbon steel bar, machine steel, and cast steel where work thickness remains constant

   (NOTE: The face of the tooth is straight to carry out chips.)

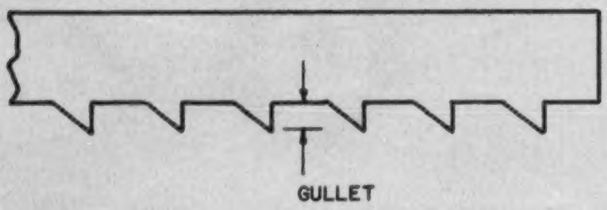
   Example:



INFORMATION SHEET

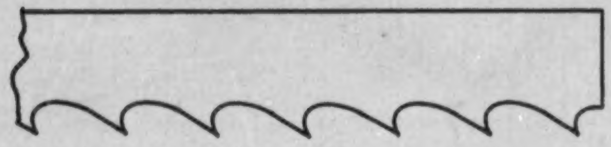
2. Skip or buttress tooth–Most commonly used on vertical band saws; recommended for very soft, non-ferrous materials such as aluminum, plastic (nylon, Teflon, Delron, etc.), and wood. The deep gullet and tooth spacing help to prevent clogging of the tooth so the material can be cut

   Example:



3. Hook or claw tooth–Most commonly used on vertical band saws; recommended for production cutting of hard, non-ferrous materials such as brass, tempered aluminum and bakelite; the claw shape of the tooth helps it penetrate and shear the materials, as well as providing space between teeth for chips to be carried through and out of the work

   Example:



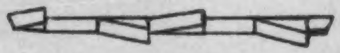
(NOTE: Skip and hook tooth shapes have raker set only.)

INFORMATION SHEET

C. Types of set for band saw blades

1. Raker set--For extended cutting where material size and shape remain constant; most commonly used for profile or contour cutting operations on a vertical band saw. The set of the teeth (right, left, and straight, or no set) allows the blade to cut as the work is turned

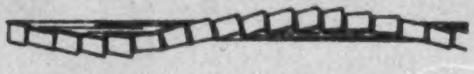
   Example:



   (NOTE: The raker set is also used for cutting with a horizontal saw where work size remains constant.)

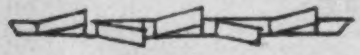
2. Wavy set--For general purpose sawing with a horizontal band saw; the wavy pattern of groups of teeth set right and then left helps eliminate tooth strippage when cutting thin sections such as pipe, angle iron, and other shapes of structural material

   Example:



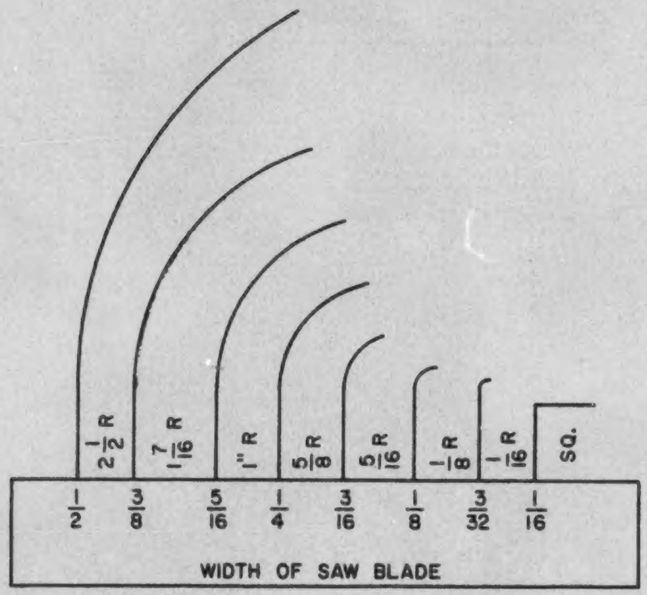
3. Alternating set--Used for cutting wood and meat; has tooth pattern of right, left, right, etc.

   Example:



INFORMATION SHEET

(NOTE: Width of blade is very important when cutting contours with a vertical band saw because a blade thickness which is too wide for the radius will bind the blade, is hard on blade guides, and takes the set out of the teeth. The chart below shows recommended widths of blades used to cut a specified radius.


$2\frac{1}{2}$ R
$1\frac{7}{16}$ R
1" R
$\frac{5}{8}$ R
$\frac{5}{16}$ R
$\frac{1}{8}$ R
$\frac{1}{16}$ R
SQ.
$\frac{1}{2}$
$\frac{3}{8}$
$\frac{5}{16}$
$\frac{1}{4}$
$\frac{3}{16}$
$\frac{1}{8}$
$\frac{3}{32}$
$\frac{1}{16}$
WIDTH OF SAW BLADE

XIII. Rules for safe use of power saws (Assignment Sheet #1)

A. Covers and guards--The saw should never be operated without covers and guards in place

B. Hands--Never touch or place hands close to moving saw blades

C. Upper guide--On a vertical band saw, should be adjusted 1/8" above surface of work

D. Eyes--Wear goggles to protect eyes from chips

E. Machine controls--Only one person should operate machine controls

F. Saw blade--Never force it or bind it

G. Scraps--Keep floor area clean and picked up

H. Pusher--Always use a wooden block to push stock through when cutting small parts

I. Broken parts or improper operation--Should be reported to your instructor

INFORMATION SHEET

J. Power--Shut off switches before adjusting any part on the machine

K. Frame lock--Horizontal band saw should be locked in upper position while setting workpiece

L. Blade--Never drop the blade on the work or shove work into blade

(NOTE: It will strip out teeth.)

M. Feed--Never apply undue pressure; let the saw do its own feeding (horizontal)

N. Long bars--Should always be supported with work support

O. Chip screen--Make sure the chip screen is installed properly to protect the coolant pump

P. Bending--Do not force the blade when doing contour work; make sure blade will cut radius without bending

Q. Burrs--Cut parts have sharp edges, and should be handled with care until they have been deburred

XIV. Care and cleaning of power saws

A. Lubrication--All grease fittings and oil levels should be checked daily

B. Brushes--Brushes that clean the chips from the blade should be replaced when worn or the chips will eat up the rubber on the wheels of the band saw

C. Coolant tank--Should be cleaned of chips and new coolant put in tank every two or three weeks

D. Chips--Clean chips from base and wheel guards daily

E. Blade--Check blade for set and missing teeth before using

F. Table--Clean vertical band saw table and wipe with light oily cloth to prevent rust

G. Guides--Check guides and rollers frequently to make sure they are properly adjusted and working

XV. Reasons for welding a band saw blade

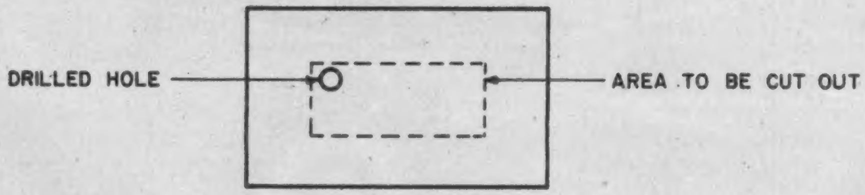
A. It is more economical to buy band saw blade material in 100 or 500 foot rolls and then cut it and make your own bands

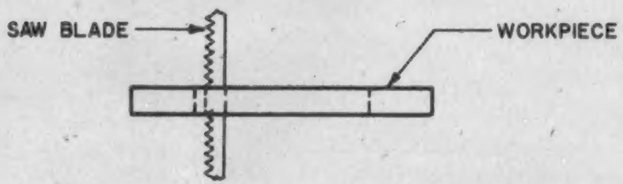
INFORMATION SHEET

B. To be able to cut material out of the interior of a part without having to cut through the exterior material

(NOTE: Cut a blade and insert it in a drilled hole, and then reweld the blade so you can cut different shapes from the inside of the work. Then cut the blade to remove it from the work and reweld.)

Example:





C. To repair a blade that has broken or has teeth stripped out by welding or cutting out damaged portion and welding in a new section

XVI. Calculating stock lengths (Assignment Sheet #2)

A. Determine the number of workpieces in which to cut stock

B. Subtract (1) from the number of workpieces to determine the number of cuts

C. Multiply the number of cuts times the width of the saw blade teeth (kerf) to determine the amount of waste

D. Add the amount of waste to the product of workpieces, times the length of each workpiece to obtain total length of the stock

E. Example:

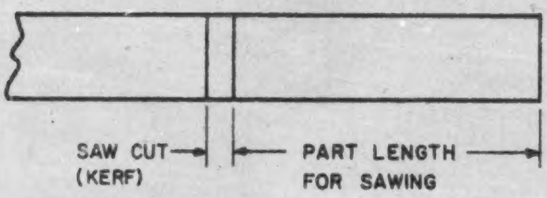
Number of pieces - (1) = Number of cuts

Number of cuts x kerf = Amount of waste

$$\text{Amount of waste} + \frac{\text{(Number of workpieces x length of each piece)}}{\text{Total length of stock}} =$$

INFORMATION SHEET

Example:

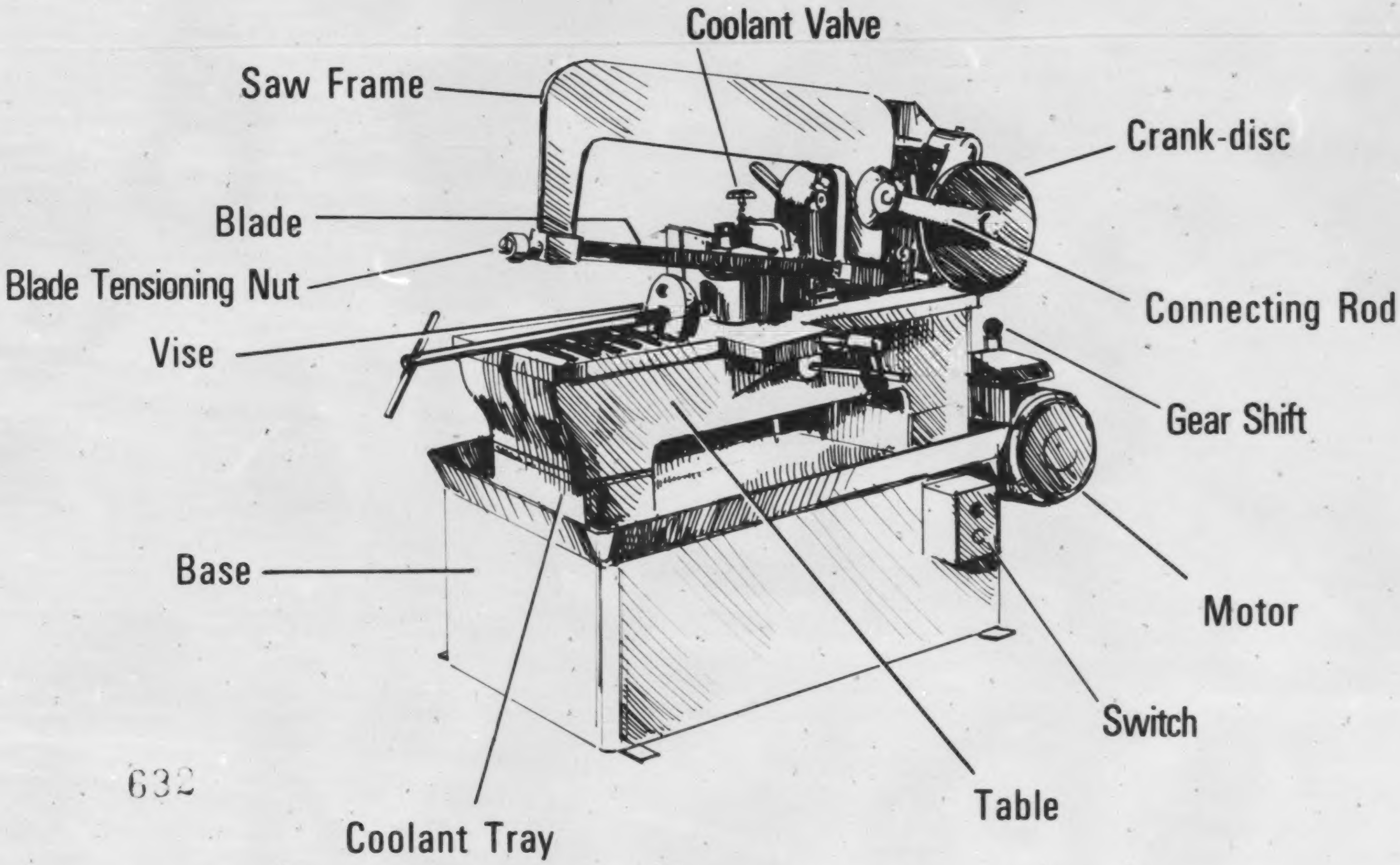


SAW LENGTH = 6 1/8 INCHES
SAW CUT = 1/8 INCH
15 PIECES REQUIRED

6 1/4 x 15 = 93 3/4 INCHES
OR 7 FEET 10 1/4 INCHES

(NOTE: Length of part will be longer than actual length so part will clean up to length, and if parts are short make sure material is long enough to cut pieces required and still have a minimum of 6 to 8" for vise to clamp on.)

Major Parts of the Reciprocating Hacksaw

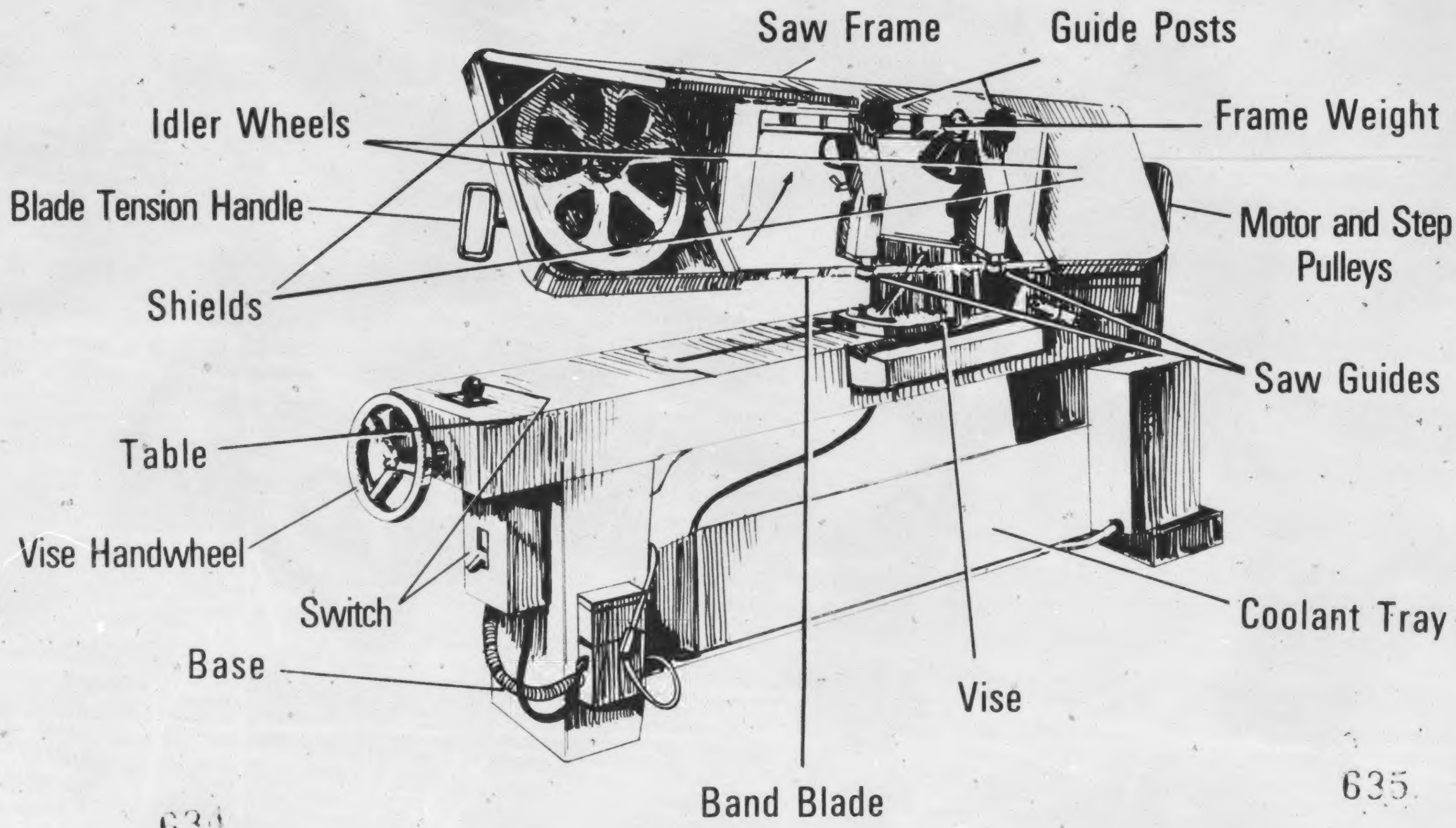

Coolant Valve
Saw Frame
Crank-disc
Blade
Blade Tensioning Nut
Connecting Rod
Vise
Gear Shift
Base
Motor
Switch
Table
Coolant Tray

632

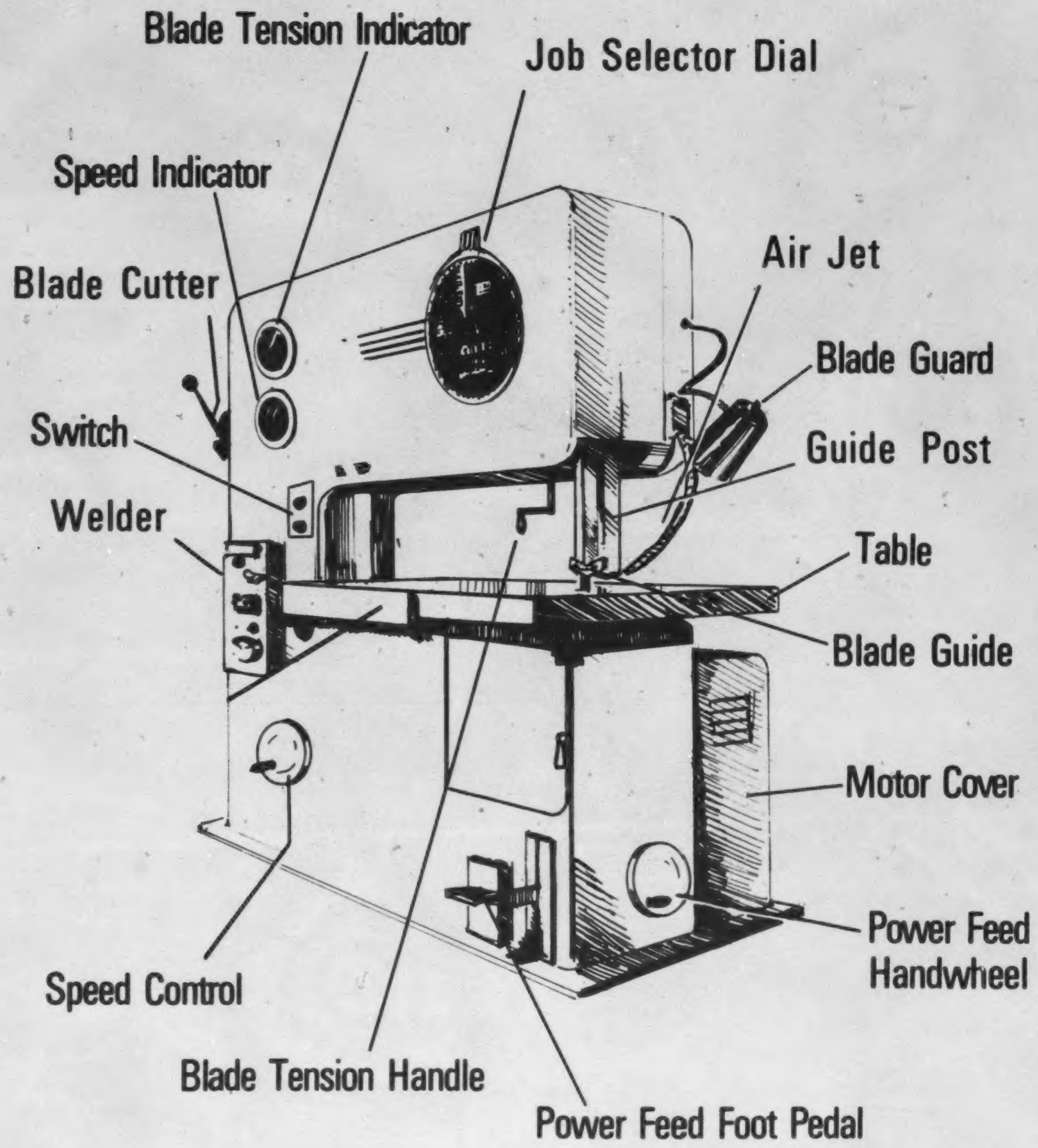
TM 1

MS I - 17-D

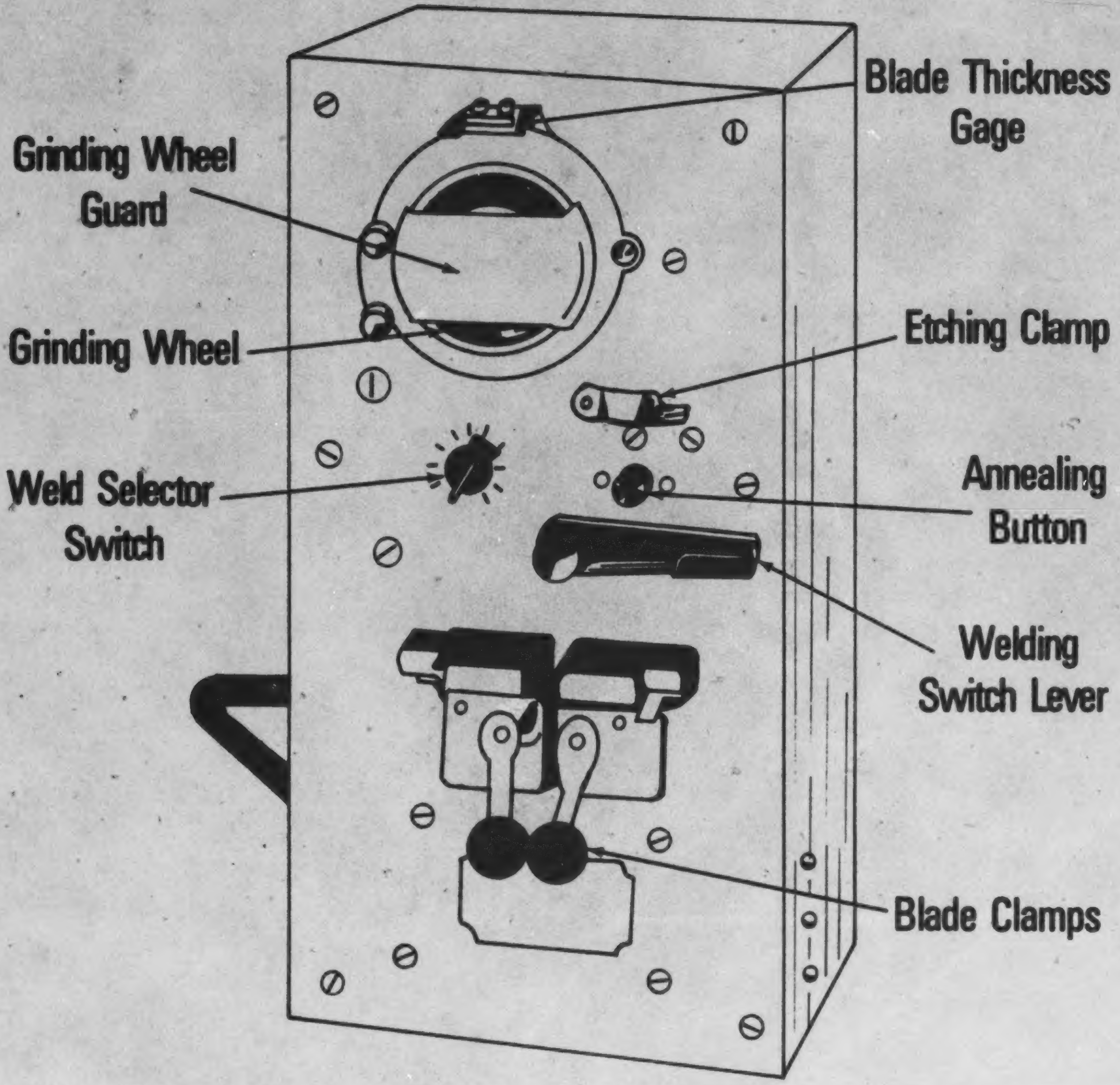
Major Parts of the Horizontal Band Saw


Saw Frame
Guide Posts
Frame Weight
Idler Wheels
Blade Tension Handle
Motor and Step Pulleys
Shields
Saw Guides
Table
Vise Handwheel
Switch
Base
Coolant Tray
Vise
Band Blade

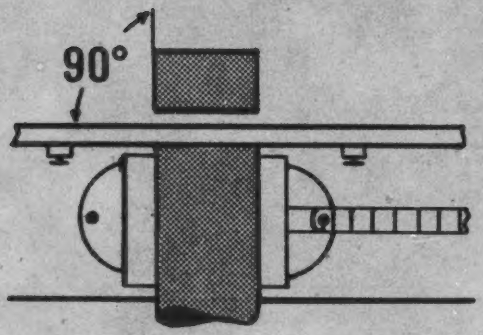
Major Parts of the Vertical Band Saw


Blade Tension Indicator
Job Selector Dial
Speed Indicator
Blade Cutter
Air Jet
Blade Guard
Switch
Guide Post
Welder
Table
Blade Guide
Motor Cover
Power Feed Handwheel
Speed Control
Blade Tension Handle
Power Feed Foot Pedal

Parts of the Butt Welder

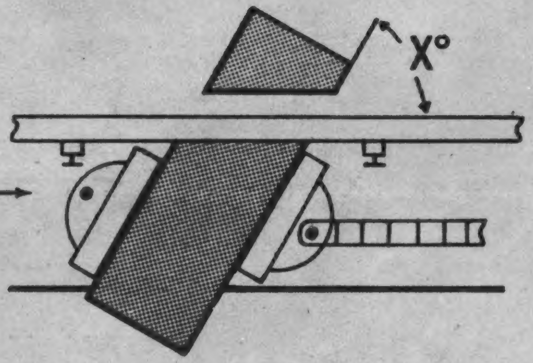

Blade Thickness Gage
Grinding Wheel Guard
Grinding Wheel
Etching Clamp
Weld Selector Switch
Annealing Button
Welding Switch Lever
Blade Clamps

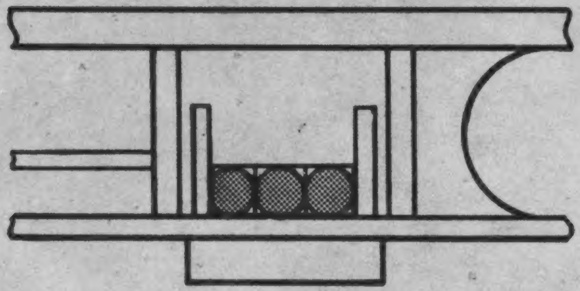
Horizontal Saw Operations



Square Cutting

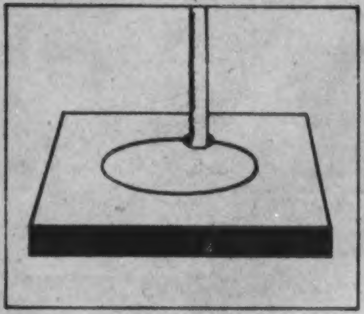
Angular Cutting



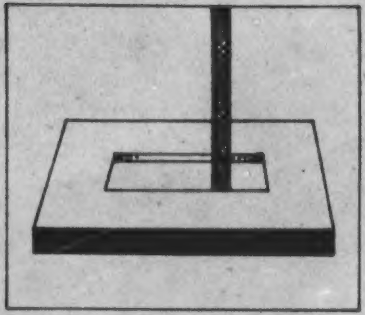


Stack Cutting

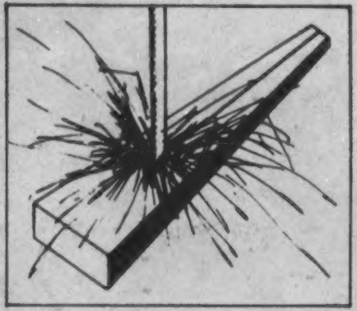
Vertical Saw Operations



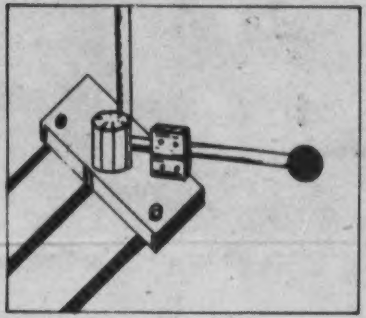
Contouring



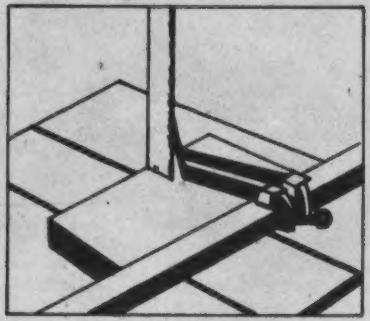
Filing



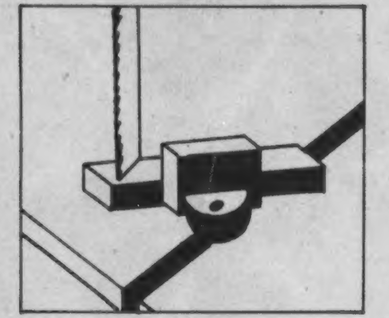
Friction Sawing



Fixture Work

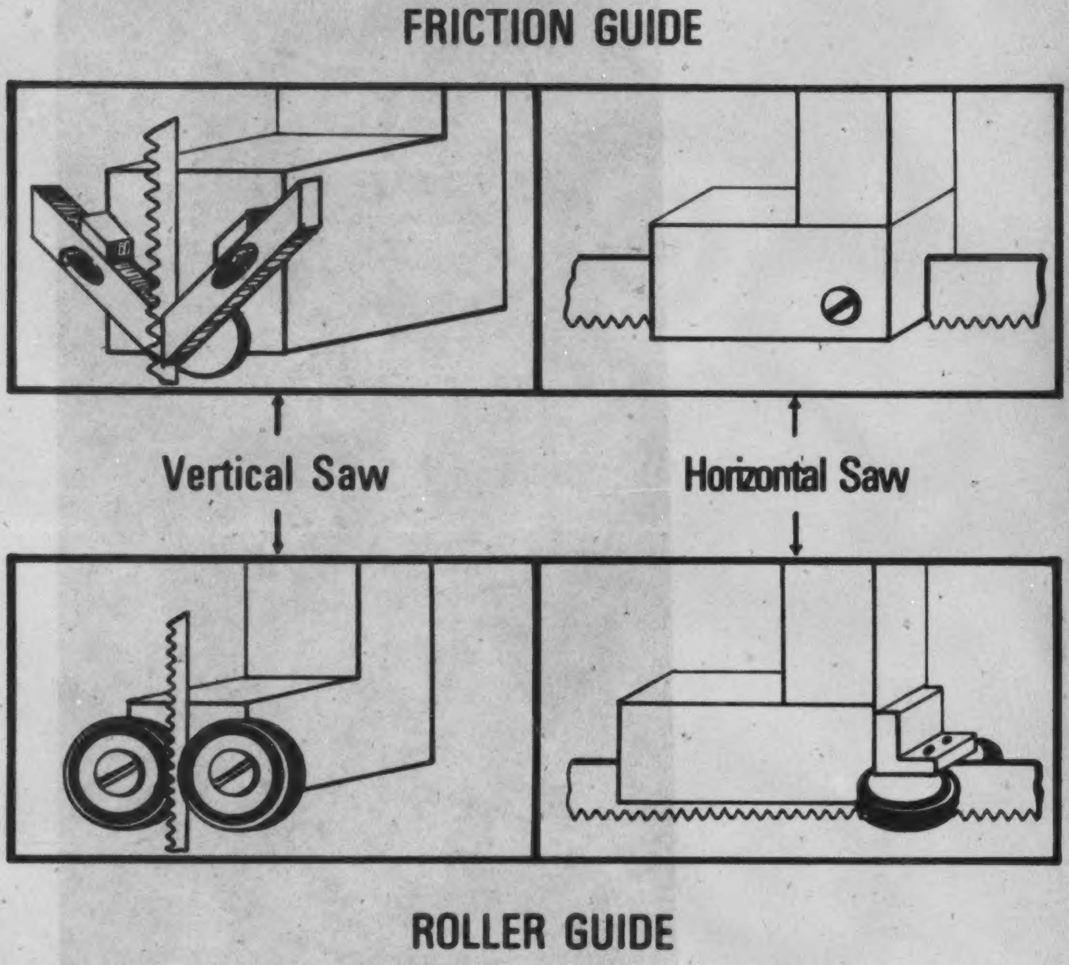


Square Cutting

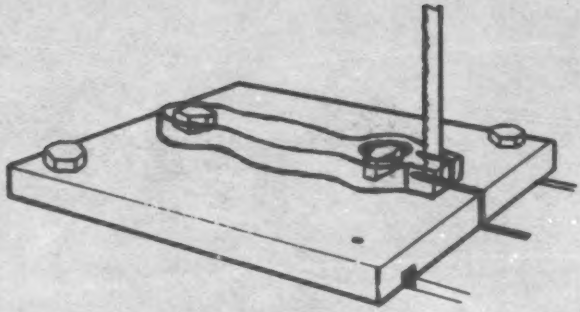


Angular Cutting

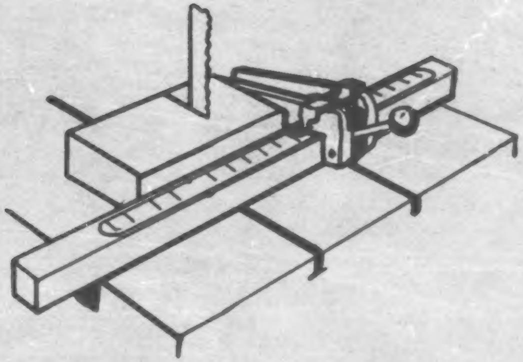
Types of Blade Guides


FRICTION GUIDE
Vertical Saw
Horizontal Saw
ROLLER GUIDE

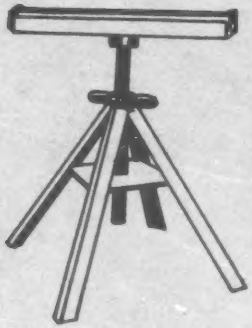
Saw Accessories



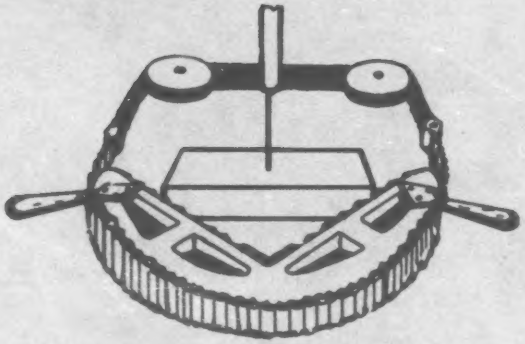
Workpiece Fixture



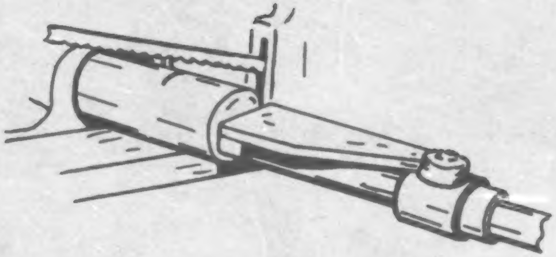
Universal Fence



Work Support

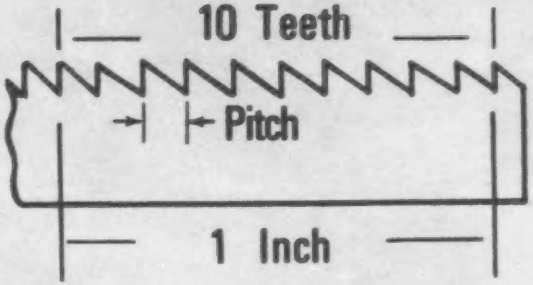


Workholding Jaws
with Feed Chain and Cable

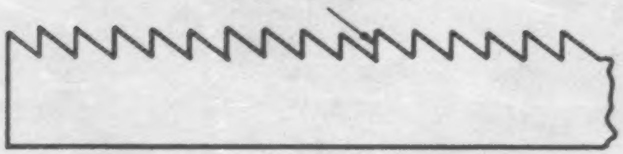


Cut-off Gage or Stop

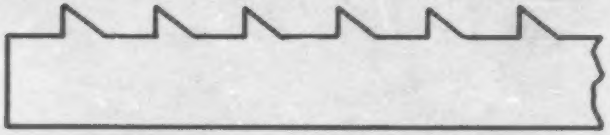
Shape and Cut of Band Saw Blades


10 Teeth
Pitch
1 Inch

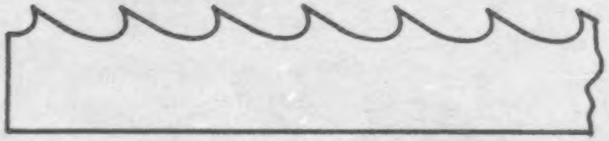
TOOTH FORM



Precision or Regular Tooth

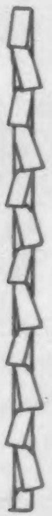


Buttress or Skip Tooth

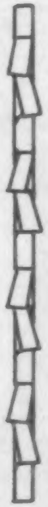


Claw or Hook Tooth

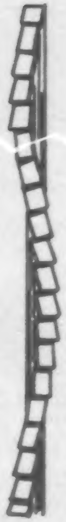
TOOTH SET



Alternate Set



Raker Set



Wavy Set

POWER SAWS
UNIT I

ASSIGNMENT SHEET #1--COMPLETE POWER SAW SAFETY TEST

NAME ______________________________ SCORE ____________

(NOTE: This test must have a score of 100 percent accuracy.)

Safety is of great concern to industry as well as to your learning process. Industry does not want time lost due to an accident, and time lost while in school is almost impossible to make up. If you learn and apply these safety rules, you will be a safer person both on the job and in school.

1. Eyes-- ______________________________
____
2. Machine controls-- ______________________________
____
3. Saw blade-- ______________________________
____
4. Scraps-- ______________________________
____
5. Pusher-- ______________________________
____
6. Broken parts or improper operation-- ______________________________
____
7. Power-- ______________________________
____
8. Frame lock-- ______________________________
____
9. Blade-- ______________________________
____
10. Feed-- ______________________________
____

ASSIGNMENT SHEET #1

11. Long bars-- ____________________

12. Chip screen-- ____________________

13. Covers and guards-- ____________________

14. Hands-- ____________________

15. Upper guide-- ____________________

16. Bending-- ____________________

17. Burrs-- ____________________

I pledge to observe all of the above rules and to check with the instructor if there is anything I am not sure about.

Signature ____________________ Date ____________

POWER SAWS
UNIT I

ASSIGNMENT SHEET #2--CALCULATE STOCK LENGTHS

NAME________________________________ SCORE ______________

Looking at a blueprint and calculating the material required is helpful in planning because many times material is cut for several jobs or parts at the same time. Practice calculating stock lengths using the formula learned earlier in this unit.

1. What total stock length is required to make 18 workpieces, each 7 1/2" long, when the kerf is 1/8" material per cut?

   a. Total stock length required______________________________

   b. How many 12' bars are required?__________________________

   c. What is the waste of each bar?___________________________

ASSIGNMENT SHEET #2

2. What total stock length is required to make 15 workpieces, each 2" long, with kerf of 1/16"?

   What length bar is required?____________________________________

   (NOTE: Add 5" to length for holding last piece for cut.)

3. What total stock length is required to make 25 workpieces, each 6 3/4" long, when the kerf is 1/16"?

   (NOTE: Stock is in 12' lengths.)

   a. Total stock length required____________________________________

   b. Number of 12' bars required?__________________________________

ASSIGNMENT SHEET #2

4. What total stock length is required to make 53 workpieces, each 7/8" long, when the kerf is 3/32" per cut?

   Answer ______________________________

5. What total stock length is required to make 17 workpieces, each 1' long, when the kerf is 1/32" material per cut?

   Answer ______________________________

POWER SAWS
UNIT I

ASSIGNMENT SHEET #3--SELECT SAW BLADE FOR DIFFERENT JOBS

NAME ________________________________ SCORE ______________

It is important to know which blade should be used for a particular job if the saw is to be fast and effective. Practice blade selection by answering the following questions.

1. State the number of teeth per inch recommended for the following thickness of materials.

_________a. 2" material

_________b. 3/4" material

_________c. 3/16" material

_________d. 5/8" material

_________e. 1/4" material

2. State the tooth shape recommended for the following materials.

______________________a. Used to cut steel bar

______________________b. Used to cut tempered aluminum plate

______________________c. Used to cut steel plate

______________________d. Used to cut plastic

______________________e. Used to cut brass bar stock

______________________f. Used to cut cast steel bar stock

______________________g. Used to cut aluminum bar

______________________h. Used to cut steel pipe

______________________i. Used to cut nylon bar stock

______________________j. Used to cut wood

3. Name the type of set recommended for the following materials.

______________________a. Used to cut wood

______________________b. Used to cut ferrous and non-ferrous curved parts on vertical band saw

______________________c. Used to cut ferrous materials on a horizontal band saw

______________________d. Used to cut profile in steel parts

______________________e. Used to cut pipe to length with a horizontal band saw

ASSIGNMENT SHEET #3

4. State number of teeth, tooth form, and set of teeth for the saw jobs described below.

   a. 1/2" tempered aluminum plate requiring contour work with 2" radius on vertical band saw

   ____________ Number of teeth
   ____________ Tooth shape
   ____________ Set of teeth
   ____________ Width of blade

   b. 3" steel bar to be cut into 40 parts 4" long using a horizontal band saw

   ____________ Number of teeth
   ____________ Tooth shape
   ____________ Set of teeth

   c. 1/4" steel plate to be cut into 50 three-inch squares on the vertical band saw

   ____________ Number of teeth
   ____________ Tooth shape
   ____________ Set of teeth

POWER SAWS
UNIT I

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

1. Eyes--Wear goggles to protect eyes from chips
2. Machine controls--Only one person should operate machine controls
3. Saw blade--Never force it or bind it
4. Scraps--Keep floor area clean and picked up
5. Pusher--Always use a wooden block to push stock through when cutting small parts
6. Broken parts or improper operation--Should be reported to your instructor
7. Power--Shut off switches before adjusting any part on the machine
8. Frame lock--Horizontal band saw should be locked in upper position while setting workpiece
9. Blade--Never drop the blade on the work or shove work into blade
10. Feed--Never apply undue pressure; let the saw do its own feeding (horizontal)
11. Long bars--Should always be supported with work support
12. Chip screen--Make sure the chip screen is installed properly to protect the coolant pump
13. Covers and guards--The saw should never be operated without covers and guards in place
14. Hands--Never touch or place hands close to moving saw blades
15. Upper guide--On a vertical band saw, should be adjusted 1/8" above surface of work
16. Bending--Do not force the blade when doing contour work; make sure the blade will cut radius without bending
17. Burrs--Cut parts have sharp edges and should be handled with care until they have been deburred

Assignment Sheet #2

1. a. 137.25"

   b. One

   c. 6 3/4"

ANSWERS TO ASSIGNMENT SHEETS

2. 35.937" or 35 15/16"
3. a. 170.312"
   b. Two
4. 51 11/32"
5. 204 17/32"

Assignment sheet #3

1. a. 6
   b. 10
   c. 24
   d. 10
   e. 18
2. a. Regular or precision tooth
   b. Hook or claw tooth
   c. Regular or precision tooth
   d. Skip or buttress tooth
   e. Hook or claw tooth
   f. Regular or precision tooth
   g. Skip or buttress tooth
   h. Regular or precision tooth
   i. Skip or buttress tooth
   j. Hook or claw tooth
3. a. Alternating set
   b. Raker set
   c. Wavy set
   d. Raker set
   e. Wavy set
4. a. 14 teeth
      Hook or claw shape
      Raker set
      2 1/2 R
   b. 4 to 6 teeth
      Regular or precision shape
      Wavy set
   c. 18 teeth
      Regular or precision shape
      Raker set

POWER SAWS
UNIT I

JOB SHEET #1--WELD A BAND SAW BLADE

I. Tools and equipment

   A. Butt welder

   B. Band saw blade material

   C. Pencil to mark blade

   D. Safety glasses

II. Procedure

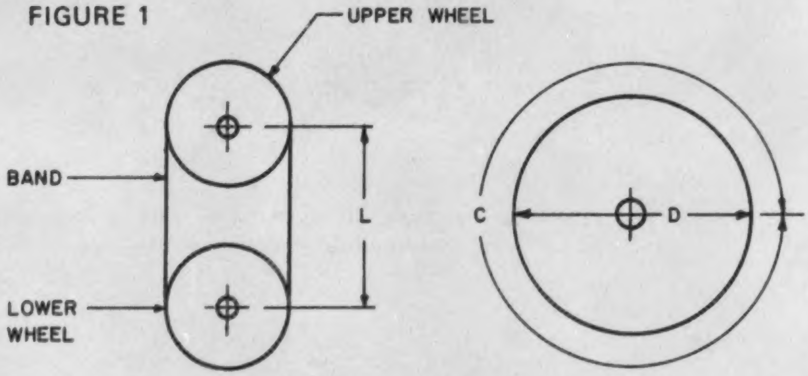
   A. Determine the length of blade required

      1. Look in operator's manual

      2. Add twice the center-to-center distance of the two wheels plus the circumference of one wheel (Figure 1)

         (NOTE: Make sure the upper wheel has been cranked down to its shortest distance and then cranked up 2 revolutions before measuring center distance of wheels.)

FIGURE 1



LENGTH CENTER TO CENTER = L

CIRCUMFERENCE = C
$C = \pi D$

   B. Roll off the required length and mark with pencil

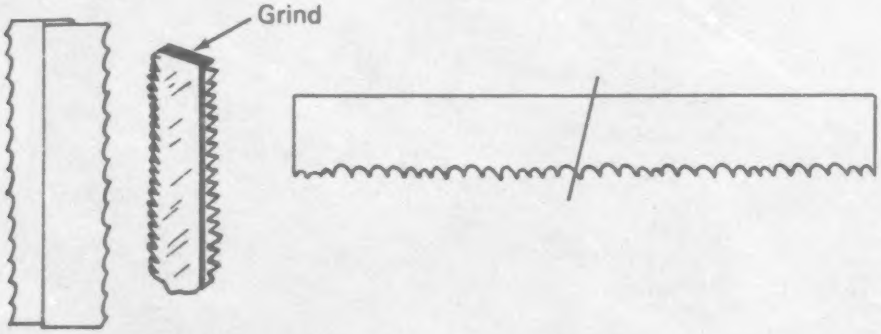
   C. Place the blade in the blade cutter and cut it to the required length

      (NOTE: Be sure to keep the blade against the blade squaring bar when cutting.)

JOB SHEET #1

D. Turn the blade back-to-back and grind both ends in one operation so that blade ends make full contact when back edge is straight (Figure 2)

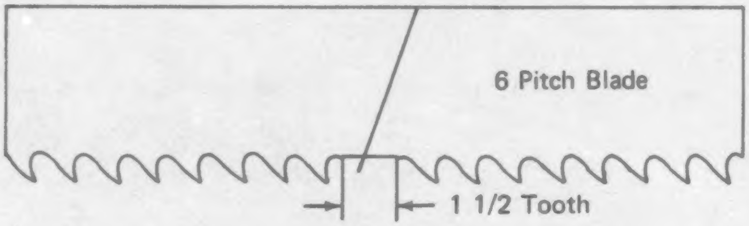
FIGURE 2



(NOTE: Even if ends are ground at an angle they will still align straight.)

E. To get the proper tooth spacing, grind off some of the teeth at the ends of the blade to the depth of the gullet (Figure 3)

FIGURE 3



(NOTE: Different pitch blades require more or less teeth to be removed and can be found by using the chart below. See Figure 4.)

FIGURE 4

4 pitch-1/2 tooth each side for a total of 1 tooth
6 pitch-3/4 tooth each side for a total of 1 1/2 teeth
8 pitch-1 tooth each side for a total of 2 teeth
10 pitch-1 1/4 teeth each side for a total of 2 1/2 teeth

F. Clean the jaws of the welder and position the inserts for the blade size and pitch

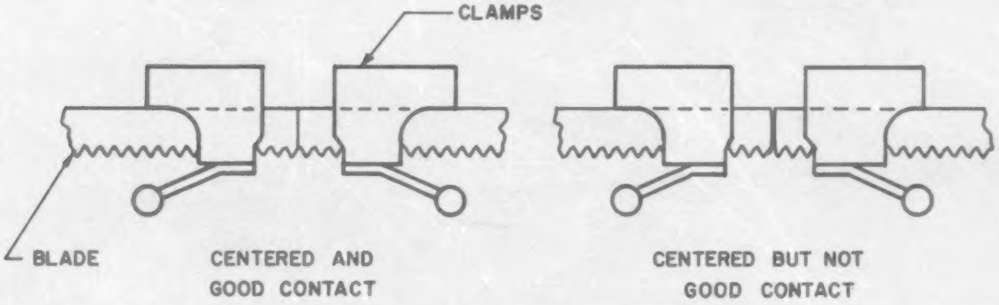
G. Set the heat indicator for the width of blade

JOB SHEET #1

H. Put the pressure selector in the weld position and clamp the blade ends so the separation is centered between the clamps; tighten clamps

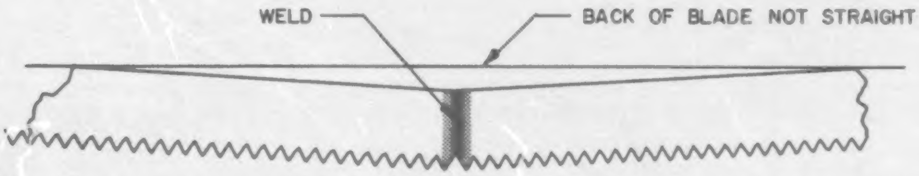
(NOTE: If the ends do not make good contact, you will get hot spots that produce holes in the weld. See Figure 5.)

FIGURE 5


CLAMPS
BLADE
CENTERED AND GOOD CONTACT
CENTERED BUT NOT GOOD CONTACT

I. Make sure the blade is against the aligning surface or the band will not run true after welding (See Figure 6)

FIGURE 6


WELD
BACK OF BLADE NOT STRAIGHT

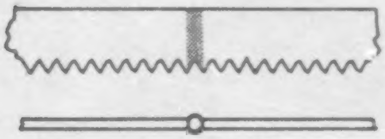
J. Depress the welding switch or push the welding lever down and hold it until the weld has cooled

(CAUTION: Stand to one side and wear safety glasses to avoid injury.)

JOB SHEET #1

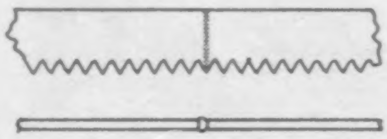
K. Examine the weld visually for quality (Figures 7, 8, and 9)

FIGURE 7



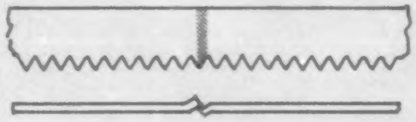
1. TOO MUCH WELD

FIGURE 8



2. NOT ENOUGH WELD

FIGURE 9



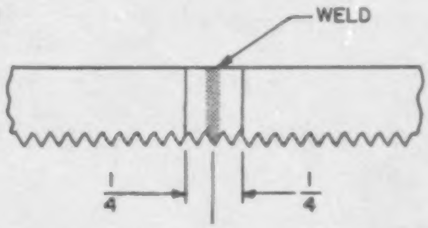
3. NOT ENOUGH HEAT OR
4. TOO MUCH PRESSURE OR
5. GUIDES NOT ALIGNED PROPERLY

L. Release the jaw clamps

M. Reset the lever to the anneal position and re-clamp the blade, making sure the weld is centered between the jaws

N. Push in the anneal button and jog it intermittently until the blade reaches a dull red color on each side of the weld for 1/4" (Figure 10)

FIGURE 10



(CAUTION: Do not permit the blade to become too hot or it will not anneal. If the anneal button is held in too long or not set properly, it will burn the blade.)

O. Jog the anneal button occasionally to permit the blade to cool slowly

P. Remove the blade and grind off the welding flash smooth with the surfaces of the blade. Be sure to keep the thickness of the weld the same as the blade; check in gage

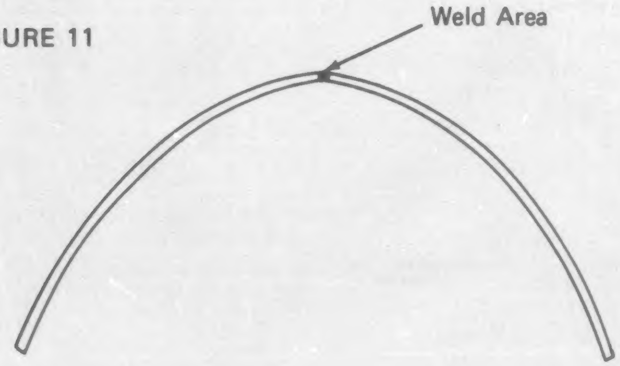
Q. Put the blade back in the jaws and clamp, then depress the anneal button, rapidly jogging it until the heat turns the area just ground to a blue color

JOB SHEET #1

R. Check the weld by flexing the blade slightly (Figure 11)

(CAUTION: Do not overflex!)

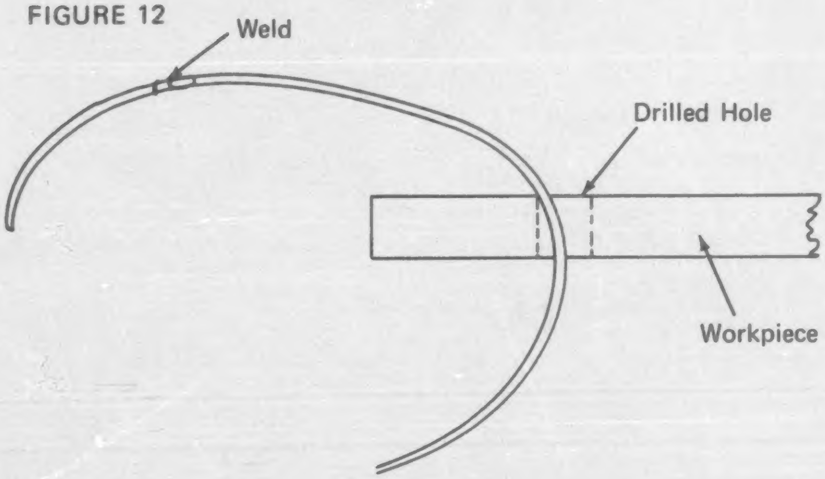
FIGURE 11



S. The blade is now ready to be mounted

(NOTE: The same process of welding would apply if you were welding the blade that has been cut and put through a drilled hole in the workpiece for cutting a shape out of a part. See Figure 12.)

FIGURE 12



T. Show instructor your weld

POWER SAWS
UNIT I

JOB SHEET #2--COIL AND UNCOIL A BAND SAW BLADE

I. Tools and equipment

   A. Band saw blade

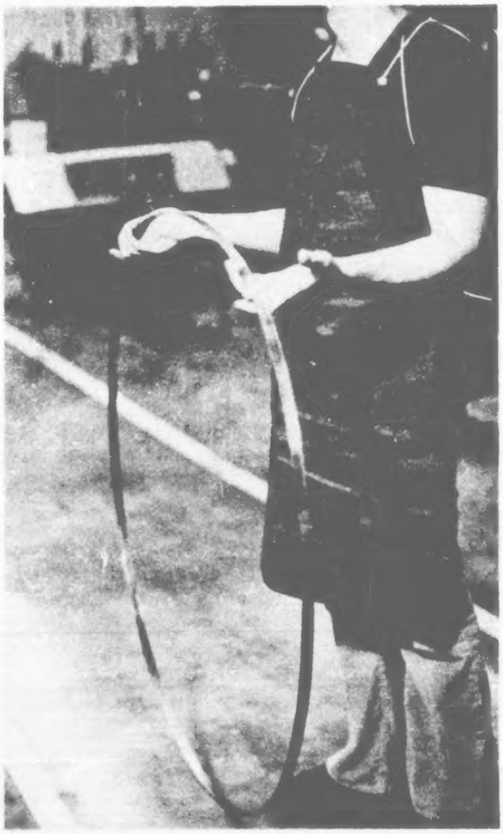
   B. Safety glasses

   C. Wire, 18 or 24 gage, 4" long

II. Procedure for coiling

   A. Hold the blade vertically with both hands, palms up, with the teeth pointing away from you (Figure 1)

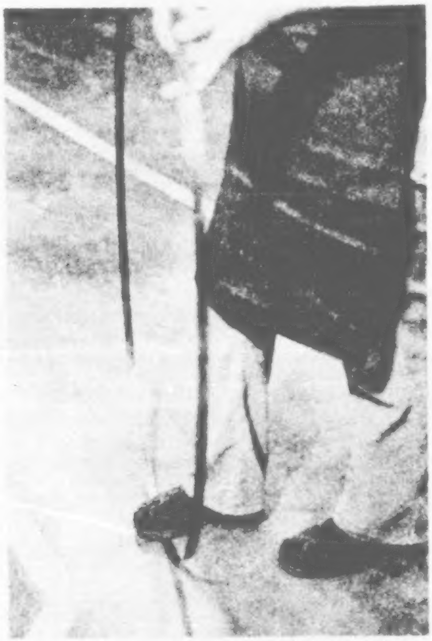
FIGURE 1



JOB SHEET #2

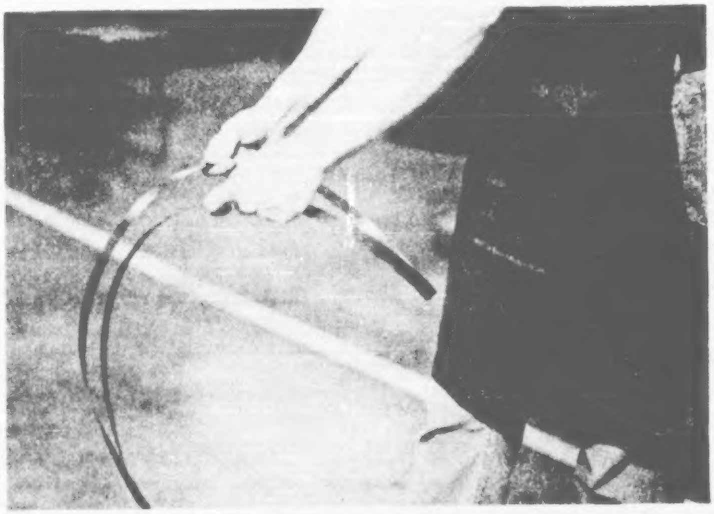
B. Put your foot on the blade and hold it to the floor (Figure 2)

FIGURE 2



C. Turn hands so palms are together and band saw folds back (Figure 3)

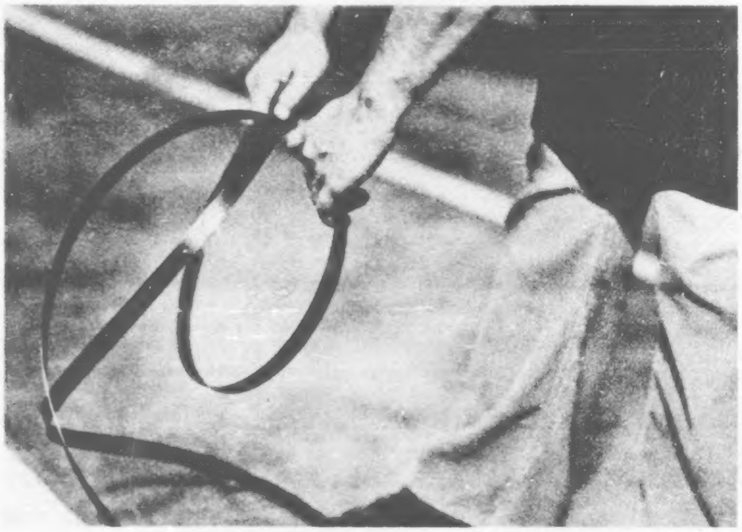
FIGURE 3



JOB SHEET #2

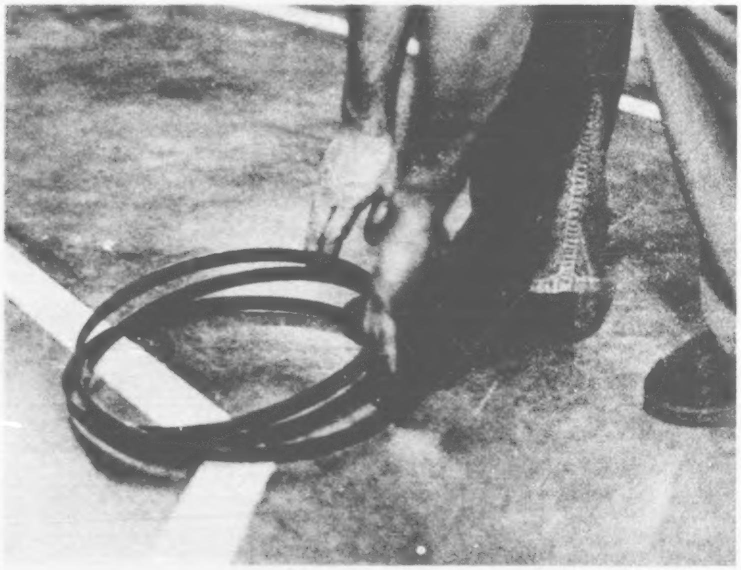
D. Continue to lower band saw blade; it will form two loops (Figure 4)

FIGURE 4



E. Lower the two loops to floor; a third loop will be formed by the part of the blade under your foot (Figure 5)

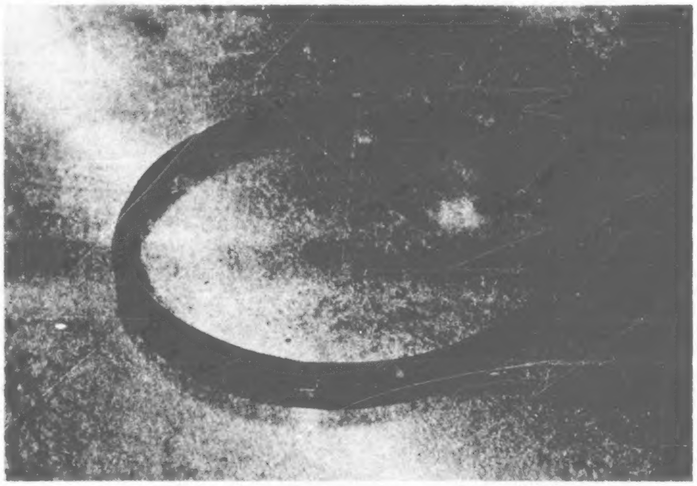
FIGURE 5



JOB SHEET #2

F. The band saw blade is now coiled and ready for storage (See Figure

FIGURE 6

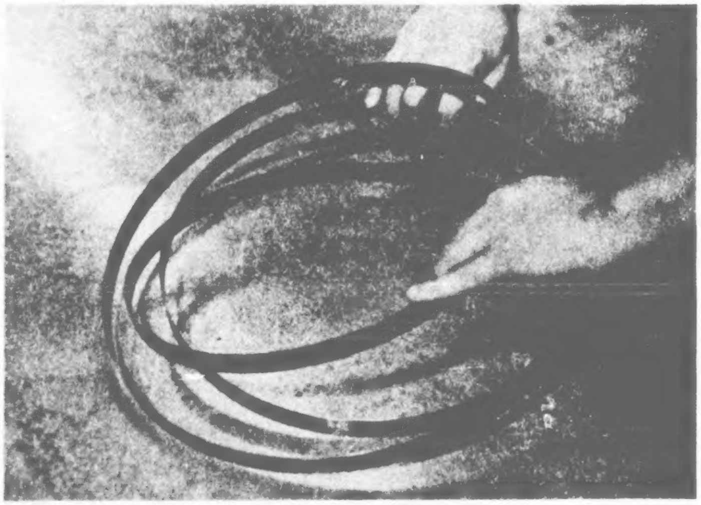


G. Tie with wire to keep from uncoiling

III. Procedure for uncoiling

A. Set coiled blade on floor; holding palms down, lift the two inside loops, one in each hand (Figure 7)

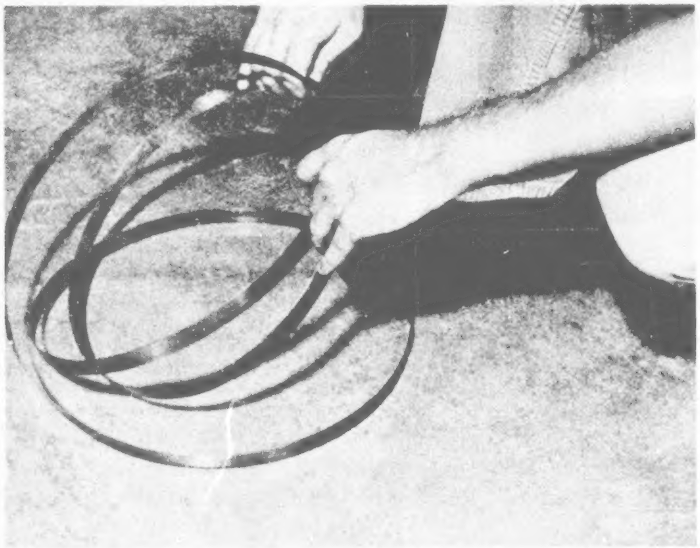
FIGURE 7



JOB SHEET #2

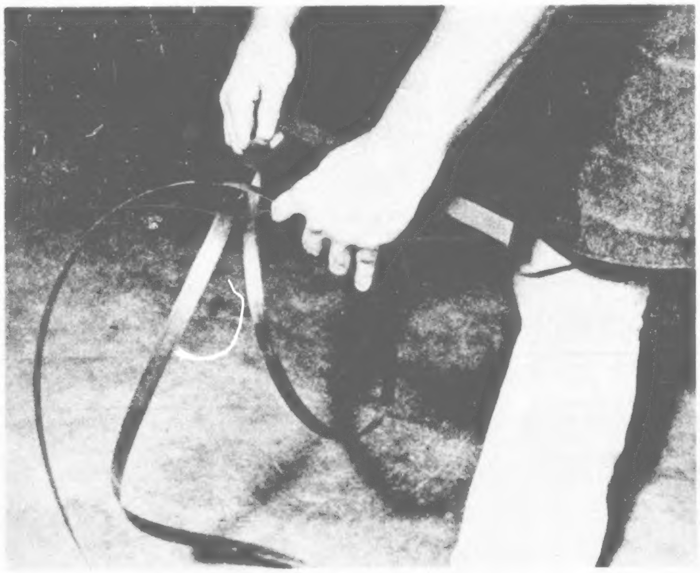
B. Step on lower loop and lift up other two loops (Figure 8)

FIGURE 8



C. Move hands farther apart and loops will uncoil (Figure 9)

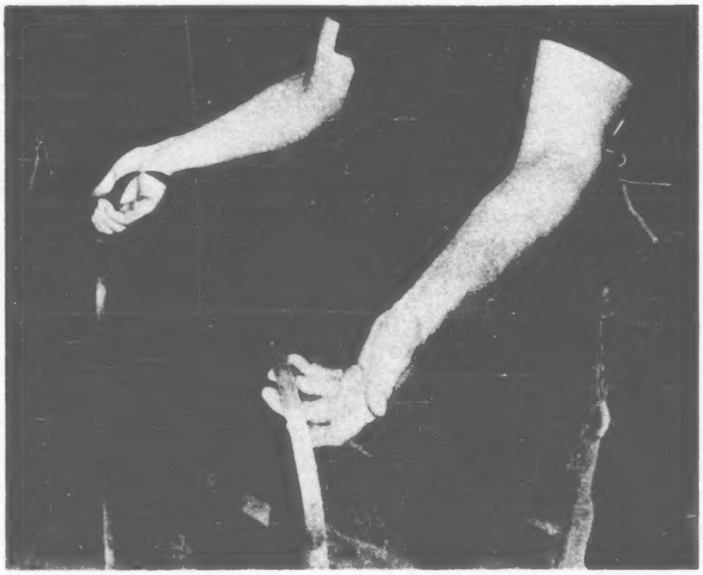
FIGURE 9



JOB SHEET #2

D. Open arms, palms out (Figure 10)

FIGURE 10



(NOTE: The blade is now ready for installation. When installing, make sure the blade is placed so teeth cut into work.)

POWER SAWS
UNIT I

JOB SHEET #3--CUT STOCK WITH HORIZONTAL BAND SAW

I. Tools and equipment

   A. Horizontal band saw

   B. 12' bar of 3/4" round 1020 CRS

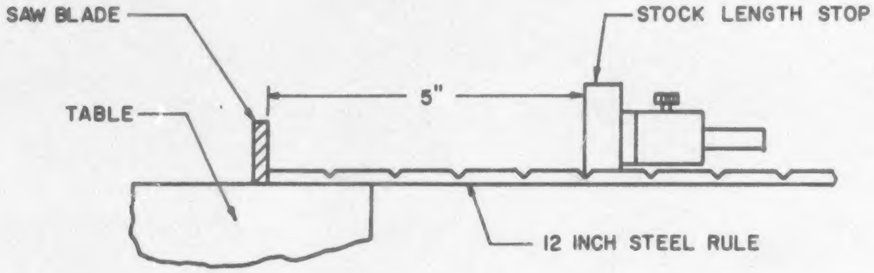
   C. Support

   D. 12" steel rule

II. Procedure

   A. With frame down, place steel rule against blade and adjust stock length stop to 5" (Figure 1)

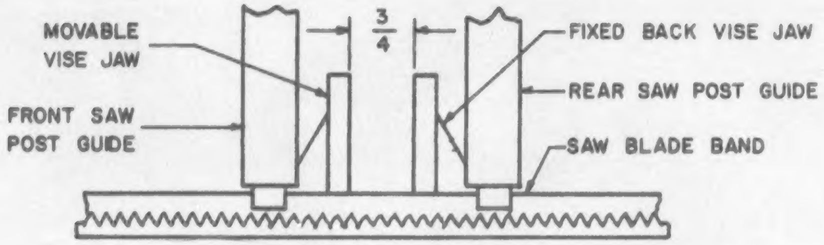
FIGURE 1


SAW BLADE
STOCK LENGTH STOP
5"
TABLE
12 INCH STEEL RULE

JOB SHEET #3

B. Adjust saw guide post so saw guide supports the band and will clear vise (Figure 2)

FIGURE 2


MOVABLE VISE JAW
FRONT SAW POST GUIDE
$\frac{3}{4}$
FIXED BACK VISE JAW
REAR SAW POST GUIDE
SAW BLADE BAND

C. Examine the blade

1. Check for missing teeth
2. Check for set of teeth
3. Check for blade tension
4. Check for correct pitch of blade

D. Raise frame and lock in up position

E. Place work support so stock will rest on table of saw and support bar while cutting

F. Slide work between jaw openings and up to stop

G. Set the saw for proper speed (90 feet per minute)

H. Check coolant level

I. Tighten vise handwheel and check part to make sure it is held securely in vise

J. Turn on power

K. Pick up frame and remove lock; lower frame until blade is setting on work and then release frame

(CAUTION: Never drop the band on the work; the sudden impact will cause the blade to bounce and shell out teeth.)

JOB SHEET #3

L. Check the first part for length and straightness of cut

M. Make adjustments if necessary

(NOTE: Stop blade before adjusting.)

N. If first part checked out, loosen vise and slide bar out to stop and cut four more parts

O. Clean up saw, return unused stock to stock room and put up steel rule

P. Deburr and clean parts

Q. Turn work into instructor

POWER SAWS
UNIT I

JOB SHEET #4--CUT STEEL BAR STOCK WITH VERTICAL BAND SAW

I. Tools and equipment

   A. Vertical band saw

   B. 5/16" x 1" x 12" 1095 steel stock

   C. 12" steel rule

   D. Scribe

   E. Wood pusher

II. Procedure

   A. Check band saw blade for:

      1. Worn teeth

      2. Missing teeth

      3. Guide alignment and adjustment

      4. Pitch of blade for 5/16" material

   B. Set blade speed at 60 feet per minute

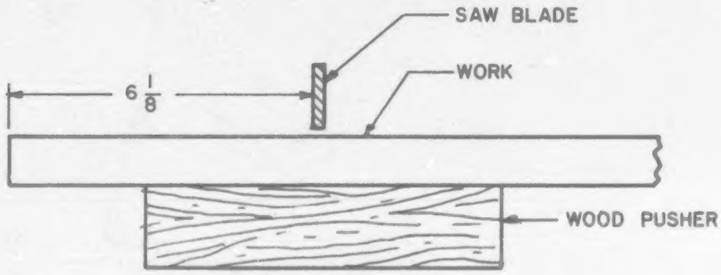
      (NOTE: Put saw in low range.)

   C. Adjust upper guide to 1/8" above thickness of work

   D. Mark part and set fence to 6 1/8"

   E. Use a wood pusher and cut part to length (Figure 1)

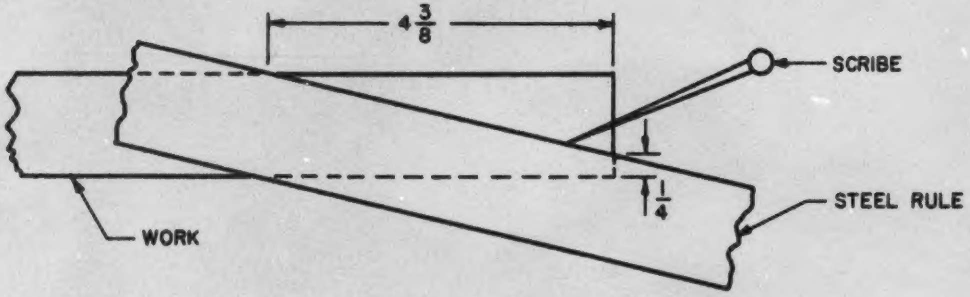
FIGURE 1



JOB SHEET #4

F. Mark angle with scribe and steel rule (Figure 2)

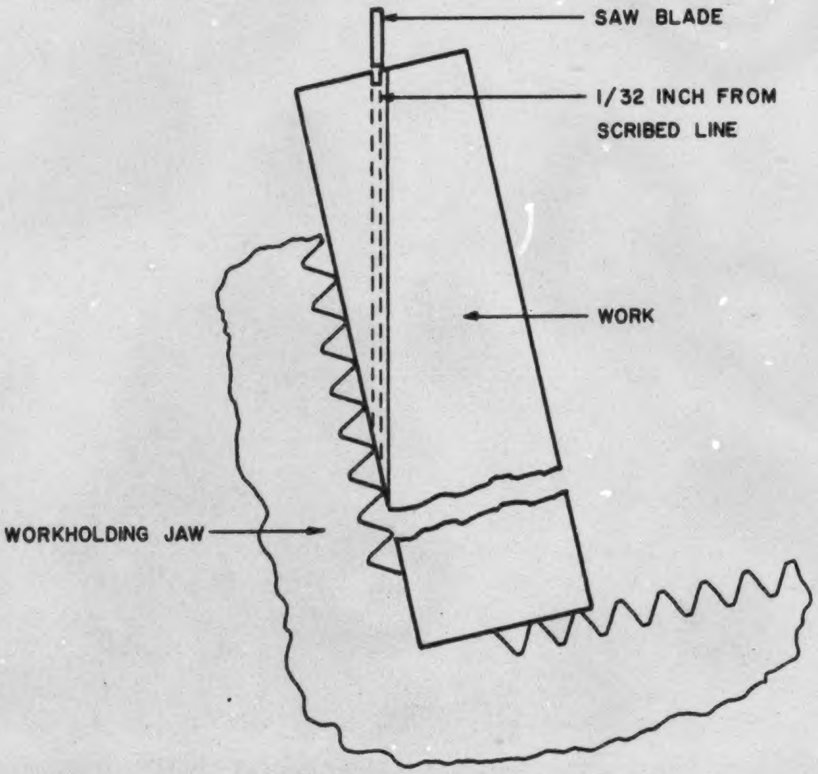
FIGURE 2


$4\frac{3}{8}$
SCRIBE
$\frac{1}{4}$
STEEL RULE
WORK

G. Use workholding jaws or wood pusher and cut angle (Figure 3)

(NOTE: Do not cut on line.)

FIGURE 3


SAW BLADE
1/32 INCH FROM SCRIBED LINE
WORK
WORKHOLDING JAW

JOB SHEET #4

H. When you are about to cut through the work, ease up on the pressure

I. Shut off the power, clean up the saw, and put all tools up

J. Deburr and clean parts

K. Turn work into instructor

POWER SAWS
UNIT I

JOB SHEET #5--CUT ALUMINUM PLATE TO LAYOUT WITH VERTICAL BAND SAW

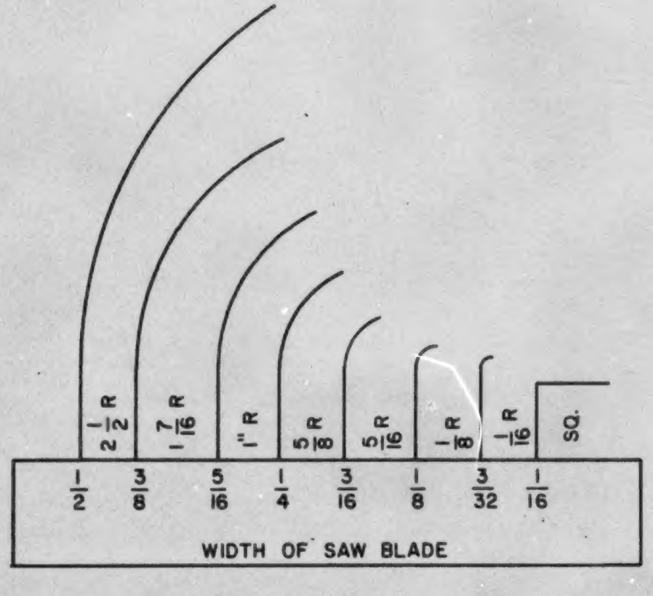
I. Tools and equipment

- A. Vertical band saw
- B. 1/2" x 8" x 8" aluminum plate
- C. Divider
- D. 12" steel rule
- E. Layout solution
- F. Scriber

II. Procedure

- A. Draw diagonals and locate center of aluminum
- B. Set divider to 3 1/2"
- C. Spray or paint layout solution on work
- D. Lay out circle with 3 1/2" radius
- E. Check saw blade to see if width of blade will allow radius of this size to be cut; if not, change band (See Figure 1)

FIGURE 1


2 1/2 R
1 7/16 R
1" R
5/8 R
5/16 R
1/8 R
1/16 R
SQ.
1/2
3/8
5/16
1/4
3/16
1/8
3/32
1/16
WIDTH OF SAW BLADE

JOB SHEET #5

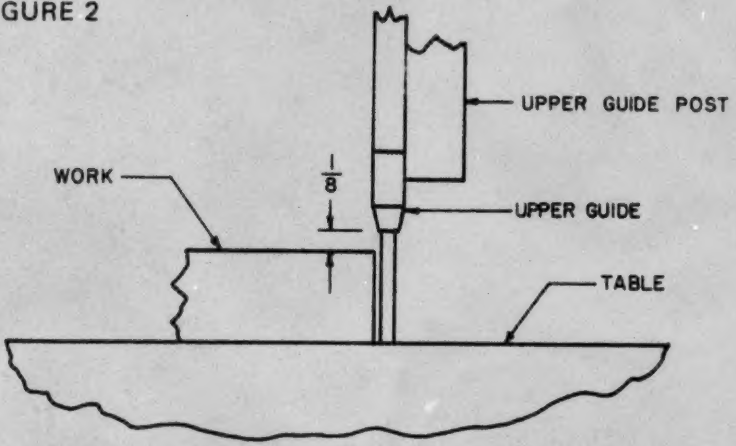
F. Check the pitch of the blade (6 pitch preferred and 8 pitch finest)

G. Set blade speed at 300 feet per minute

(NOTE: Speeds may be obtained from chart located on some machines.)

H. Set upper guide 1/8" above work (Figure 2)

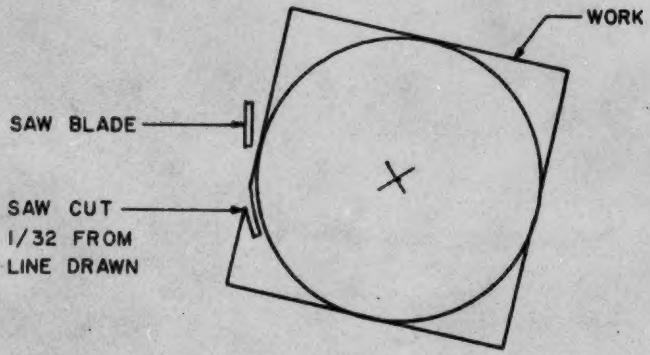
FIGURE 2


UPPER GUIDE POST
WORK
$\frac{1}{8}$
UPPER GUIDE
TABLE

I. Use the workholding jaws or radius cutting attachment and start cutting

(CAUTION: Do not force cut; allow the saw to cut before turning or you will knock the set off the inside of the band. See Figure 3.)

FIGURE 3


WORK
SAW BLADE
SAW CUT
1/32 FROM
LINE DRAWN

JOB SHEET #5

J. Feed the work into the teeth and at the same time turn the work; continue this process until circle has been cut out

K. Clean up saw, put scraps in box for aluminum

L. Put all tools up

M. Deburr sharp edges of parts

N. Turn work in to instructor

POWER SAWS
UNIT I

TEST

NAME ____ SCORE ________________

1. Match terms associated with power saws to the correct definitions. Write the correct numbers in the blanks.

_____a. Part made to hold work that will have other work performed on it

_____b. Space from top of tooth to bottom

_____c. Distance from one tooth to corresponding point of the next tooth

_____d. Amount of material consumed each time the saw makes a cut

_____e. Method of rolling up a saw blade

_____f. Cutting a shape that is not straight

_____g. Distance around a round object

_____h. Use of speed and heat to saw

_____i. The bending of a portion of every other tooth toward one side and the alternate teeth toward the opposite side to allow clearance for the blade thickness

_____j. Number of feet of the blade that pass through the work in one minute (sfpm)

1. Kerf
2. Set
3. Contouring
4. Cutting speed
5. Fixture
6. Friction sawing
7. Pitch
8. Gullet
9. Circumference
10. Coiling

2. Match types of power saws to the correct definitions. Write the correct numbers in the blanks.

a. ______________________--Consists of a base with vise and a frame with two wheels that carries a saw blade and adjustable saw guides; is motor driven with v-belts and pulleys for different band speeds

b. ______________________--Consists of a base with table and idler wheels that carry a saw blade with adjustable upper saw guide; is motor driven with speeds obtained by transmission or variable speed pulley

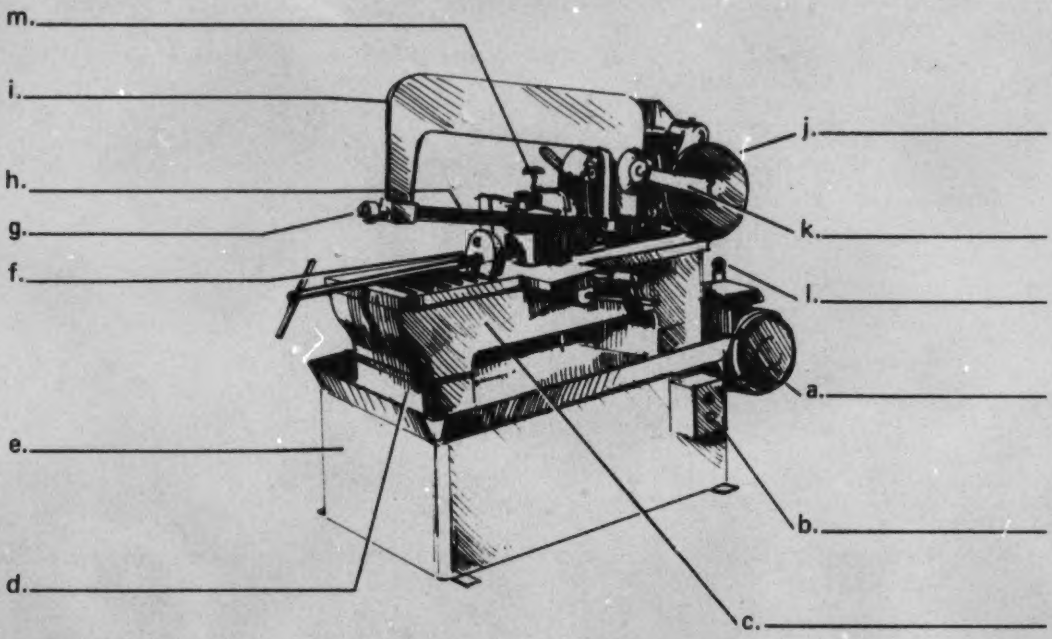
c. ______________________--Consists of a base with vise and a frame with saw blade that moves back and forth by means of a cam; is motor driven, with a v-belt and pulley for different speeds

1. Reciprocating hacksaw
2. Horizontal band saw
3. Vertical band saw

3. Identify major parts of a reciprocating hacksaw. Write the correct names in the blanks.

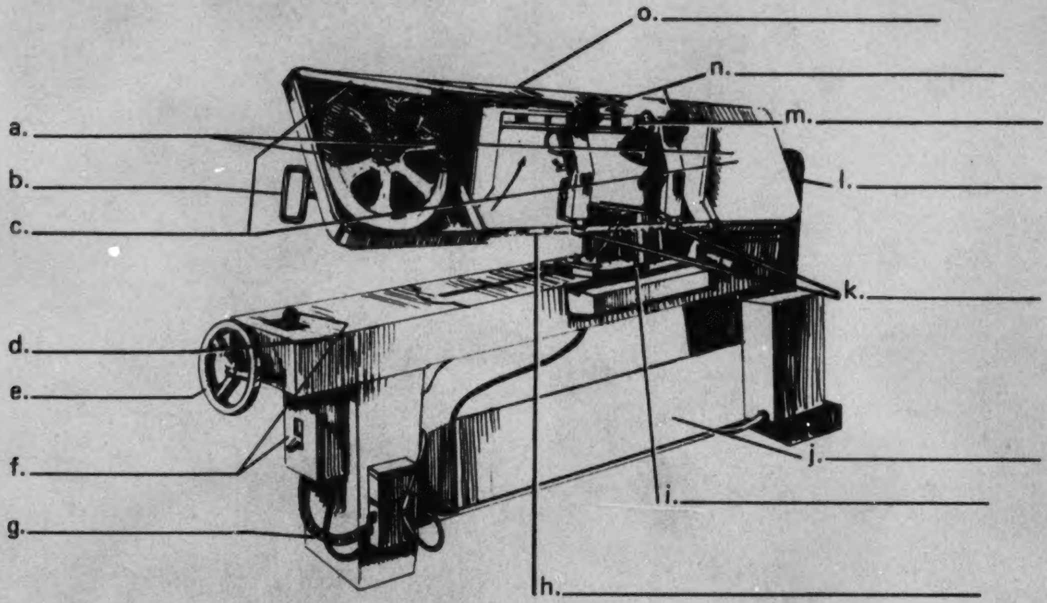
Table
Switch
Motor
Gear shift
Connecting rod
Crank-disc

Saw frame
Coolant valve
Blade tensioning nut
Vise
Base
Coolant tray
Blade



4. Identify major parts of a horizontal band saw. Write the correct names in the blanks.

Blade tension handle
Vise handwheel
Shields
Base
Saw guides
Guide posts
Idler wheels
Band blade
Switch
Vise
Saw frame
Frame weight
Coolant tray
Table
Motor and step pulleys

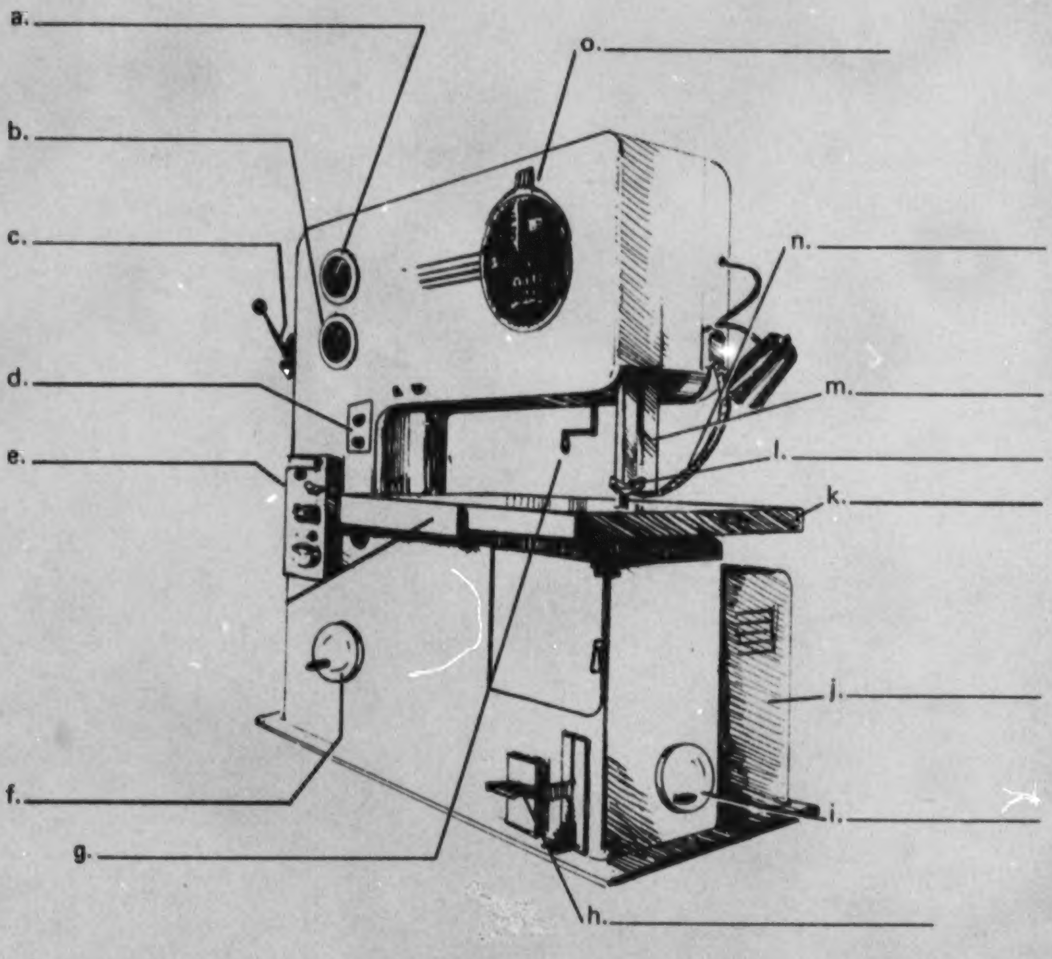


5. Identify major parts of a vertical band saw. Write the correct names in the blanks.

Blade guide
Blade cutter
Welder
Power feed foot pedal
Speed indicator

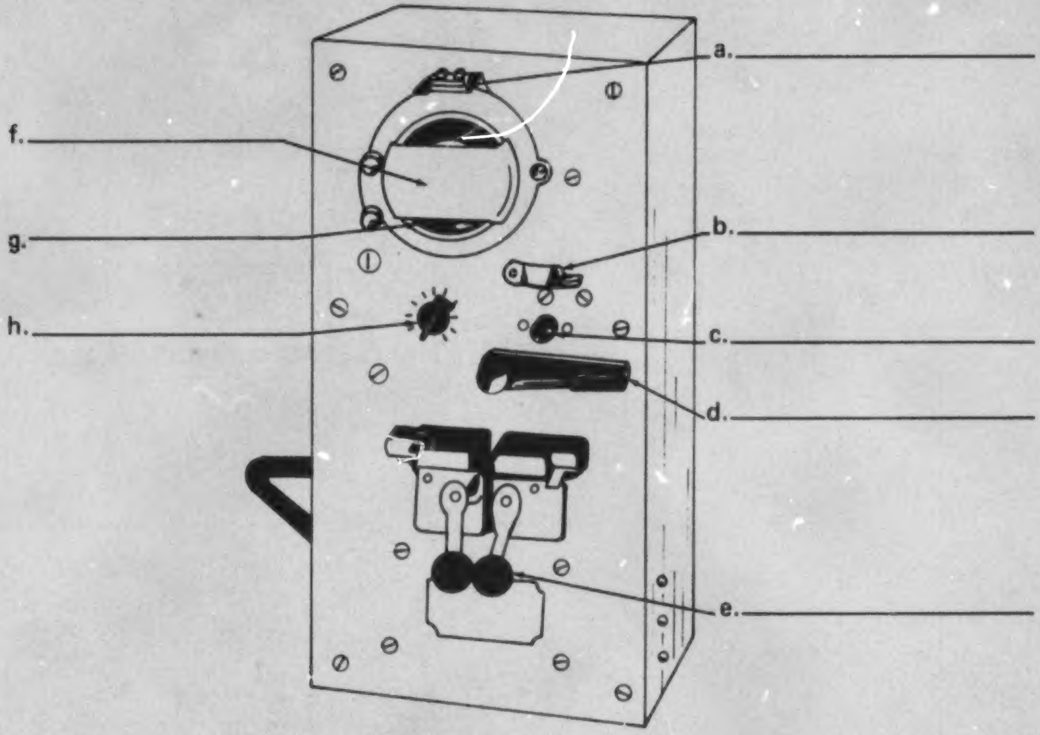
Speed control
Power feed handwheel
Table
Air jet
Blade tension handle

Guide post
Blade tension indicator
Job selector dial
Motor cover
Switch



6. Identify major parts of the butt welder. Write the correct names in the blanks.

Grinding wheel guard	Blade clamps
Welding switch lever	Annealing button
Weld selector switch	Etching clamp
Blade thickness gage	Grinding wheel



7. Distinguish between operations that can be performed on a horizontal band saw and operations that can be performed on a vertical band saw. Place an "H" beside operations of the horizontal saw and a "V" beside operations of the vertical band saw. Some blanks may have more than one answer.

_____a. Filing

_____b. Square cutting

_____c. Angular cutting

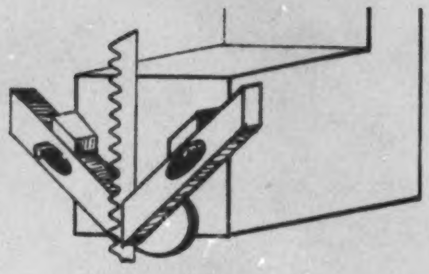
_____d. Contouring

_____e. Stack cutting

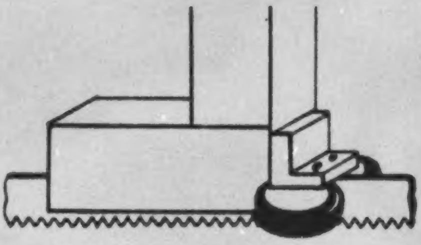
_____f. Fixture work

8. Identify types of blade guides seen in the illustrations below. Write the correct names in the blanks.

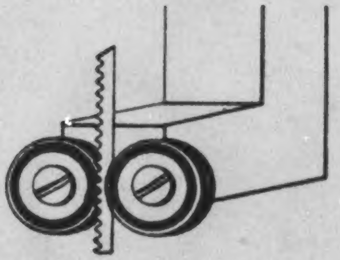
Friction guide
Roller guide
Roller guide
Friction guide



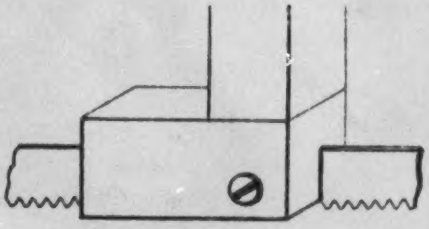
a. ______________________



b. ______________________



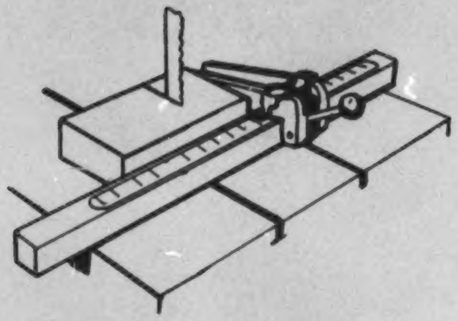
c. ______________________



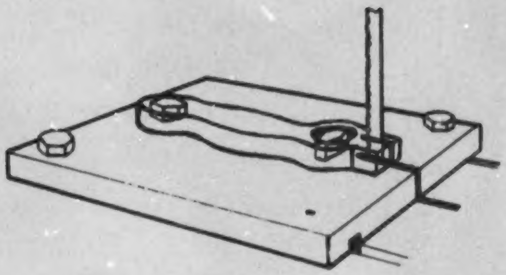
d. ______________________

9. Identify accessories used with power saws shown in the following illustrations. Write the correct names in the blanks.

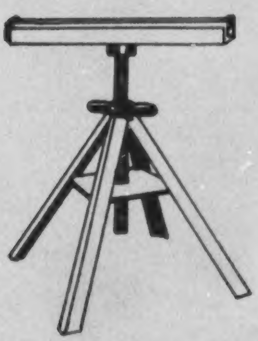
Workpiece fixture
Universal fence
Work support
Workholding jaws with feed chain and cable
Cut-off gage or stop



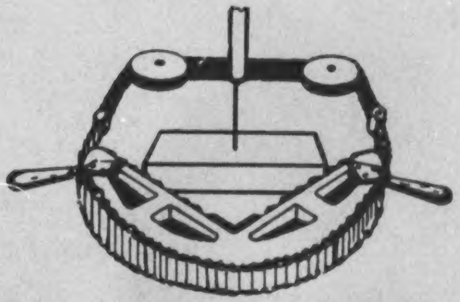
a. ______________________



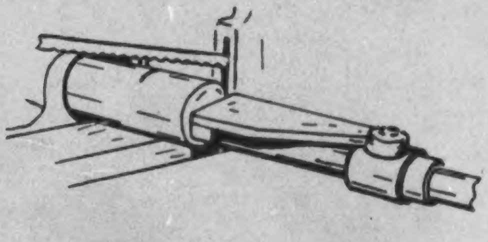
b. ______________________



c. ______________________



d. ______________________



e. ______________________

10. List methods for determining band saw speeds for different materials.

a. ______________________________

b. ______________________________

11. Select from a list factors that determine saw blade selection. Mark each correct answer with an "X."

_____a. Whether it is a vertical or horizontal saw

_____b. Material

_____c. Type of coolant

_____d. Type of job

_____e. Speed of the blade

_____f. Thickness of material

_____g. Length of the band

_____h. Width of blade

12. Select the correct saw blades for different jobs. Use the chart below and write the correct numbers in the blanks.

Material Thickness	Tooth Per Inch	Pitch
1/8" to 3/16"	24 teeth	.041
1/4" to 5/16"	18 teeth	.055
3/8" to 7/16"	14 teeth	.071
1/2" to 3/4"	10 teeth	.100
13/16" to 1"	8 teeth	.125
1 1/16" to 3"	6 teeth	.166
over 3"	4 teeth	.250

_____a. Used on a horizontal band saw to cut a machine steel bar 2" square

_____b. Used on a vertical band saw to cut 3/4" thick tempered aluminum plate

_____c. Used on a vertical band saw to cut a contoured surface in machine steel plate 1" thick

_____d. Used on a horizontal band saw to cut a 4" diameter steel pipe with 1/2" wall thickness

_____e. Use on a vertical band saw to cut a plastic (nylon) part from plate material 3/4" thick

1. Skip tooth, raker set with 10 teeth
2. Regular tooth, raker set with 10 teeth
3. Regular tooth, raker set with 6 teeth
4. Hook tooth, raker set with 10 teeth
5. Regular tooth, raker set with 18 teeth
6. Regular tooth, raker set with 8 teeth
7. Regular tooth, wavy set with 10 teeth

_____f. Used on a vertical band saw to cut a slat in high carbon steel workpiece 1/2" thick

_____g. Used on a vertical band saw to cut machine steel plate 5/16" thick

13. State rules for safe use of power saws in the spaces below.

a. Covers and guards-- ______________________________

____

____

b. Hands-- ______________________________

____

c. Upper guide-- ______________________________

____

d. Eyes-- ______________________________

____

e. Machine controls-- ______________________________

____

f. Saw blade-- ______________________________

____

g. Scraps-- ______________________________

____

h. Pusher-- ______________________________

____

i. Broken parts or improper operation-- ______________________________

____

j. Power-- ______________________________

____

k. Frame lock-- ______________________________

____

l. Blade-- ______________________________

____

m. Feed-- ____

____

n. Long bars-- ____________________________________

____

o. Chip screen-- ___________________________________

____

p. Bending-- ______________________________________

____

q. Burrs-- _______________________________________

____

14. Describe care and cleaning of power saws in the spaces below.

a. Lubrication-- ___________________________________

____

b. Brushes-- ______________________________________

____

c. Coolant tank-- __________________________________

____

d. Chips-- _______________________________________

____

e. Blade-- _______________________________________

____

f. Table-- _______________________________________

____

g. Guides-- ______________________________________

____

15. State reasons for welding a band saw blade in the blanks below.

a. ____

____

b. ______________________________

____

c. ______________________________

____

16. Calculate stock lengths to obtain 54 pieces of 2" steel bar 5 1/8" long.

(NOTE: Stock is cut 1/8" more than finished length. Allow 1/16" for each saw end. Stock comes in 12' lengths.)

a. How many 12' parts will be required? ____________

b. How much waste will there be on each bar? ____________

17. Complete power saw safety test.

18. Demonstrate the ability to:

a. Weld a band saw blade.

b. Coil and uncoil a band saw blade.

c. Cut stock with horizontal band saw.

d. Cut steel bar stock with vertical band saw.

e. Cut aluminum plate to layout with vertical band saw.

(NOTE: If activities 17 and 18 have not been finished before the test, ask your instructor when they should be completed.)

POWER SAWS
UNIT I

ANSWERS TO TEST

(NOTE: The point system designated in parentheses is intended to be a guideline and should be adapted as needed. The point total is 475.)

1. (20 points)
    - a. 5
    - b. 8
    - c. 7
    - d. 1
    - e. 10
    - f. 3
    - g. 9
    - h. 6
    - i. 2
    - j. 4
2. (6 points)
    - a. 2
    - b. 3
    - c. 1
3. (26 points)
    - a. Motor
    - b. Switch
    - c. Table
    - d. Coolant tray
    - e. Base
    - f. Vise
    - g. Blade tensioning nut
    - h. Blade
    - i. Saw frame
    - j. Crank-disc
    - k. Connecting rod
    - l. Gear shift
    - m. Coolant valve
4. (30 points)
    - a. Idler wheels
    - b. Blade tension handle
    - c. Shields
    - d. Table
    - e. Vise handwheel
    - f. Switch

g. Base

h. Band blade

i. Vise

j. Coolant tray

k. Saw guides

l. Motor and step pulleys

m. Frame weight

n. Guide posts

o. Saw frame

5. (30 points)

a. Blade tension indicator

b. Speed indicator

c. Blade cutter

d. Switch

e. Welder

f. Speed control

g. Blade tension handle

h. Power feed foot pedal

i. Power feed handwheel

j. Motor cover

k. Table

l. Blade guide

m. Guide post

n. Air jet

o. Job selector dial

6. (16 points)

a. Blade thickness gage

b. Etching clamp

c. Annealing button

d. Welding switch lever

e. Blade clamps

f. Grinding wheel guard

g. Grinding wheel

h. Weld selector switch

7. (16 points)

a. V

b. V, H

c. V, H

d. V

e. H

f. V

8. (4 points)

   a. Friction guide

   b. Roller guide

   c. Roller guide

   d. Friction guide

9. (10 points)

   a. Universal fence

   b. Workpiece fixture

   c. Work support

   d. Workholding jaws with feed chain and cable

   e. Cut-off gage or stop

10. (2 points)

    a. Job selector dial on saw

    b. Machinist's handbook

11. (16 points)

    b, d, f, h

12. (14 points)

a.	3	e.	1
b.	4	f.	2
c.	6	g.	5
d.	7		

13. (51 points)

    a. Covers and guards--The saw should never be operated without covers and guards in place

    b. Hands--Never touch or place hands close to moving saw blades

    c. Upper guide--On a vertical band saw, should be adjusted 1/8" above surface of work

    d. Eyes--Wear goggles to protect eyes from chips

e. Machine controls--Only one person should operate machine controls

f. Saw blade--Never force it or bind it

g. Scraps--Keep floor area clean and picked up

h. Pusher--Always use a wooden block to push stock through when cutting small parts

i. Broken parts or improper operation--Should be reported to your instructor

j. Power--Shut off switches before adjusting any part on the machine

k. Frame lock--Horizontal band saw should be locked in upper position while setting workpiece

l. Blade--Never drop the blade on the work or shove work into blade

m. Feed--Never apply undue pressure; let the saw do its own feeding (horizontal)

n. Long bars--Should always be supported with work support

o. Chip screen--Make sure the chip screen is installed properly to protect the coolant pump

p. Bending--Do not force the blade when doing contour work; make sure the blade will cut radius without bending

q. Burrs--Cut parts have sharp edges, and should be handled with care until they have been deburred

14. (21 points)

a. Lubrication--All grease fittings and oil levels should be checked daily

b. Brushes--Brushes that clean the chips from the blade should be replaced when worn or the chips will eat up the rubber on the wheels of the band saw

c. Coolant tank--Should be cleaned of chips and new coolant put in tank every two or three weeks

d. Chips--Clean chips from base and wheel guards daily

e. Blade--Check blade for set and missing teeth before using

f. Table--Clean vertical band saw table and wipe with light oily cloth to prevent rust

g. Guides--Check guides and rollers frequently to make sure they are properly adjusted and working

15. (3 points)

    a. It is more economical to buy band saw blade material in 100 or 500 foot rolls and then cut it and make your own bands

    b. To be able to cut material out of the interior of a part without having to cut through the exterior material

    c. To repair a blade that has broken or has teeth stripped out by welding or cutting out damaged portion and welding in a new section

16. (10 points)

    a. 2

    b. 9/16"

17. (100 points) Evaluated to satisfaction of instructor

18. (100 points) Performance skills evaluated to satisfaction of instructor

DRILL PRESS
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to demonstrate safe and proper use of the drill press in performing drilling, reaming, countersinking, and counterboring operations to specifications. This knowledge will be shown by completion of assignment sheets, job sheets, and unit test with a minimum score of 85 percent accuracy.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with drill press operations to the correct definitions.
2. Identify types of drill presses.
3. Describe the function of a drill press.
4. Identify major parts of a drill press.
5. Match operations performed on a drill press to the correct definitions.
6. Name cutting tools used for drill press operations.
7. Describe types of drill press spindle drives.
8. Identify workholding and set-up devices used in drill press operations.
9. Identify attachments and accessories used with drill presses.
10. List methods of applying coolants.
11. State rules for safe use of drilling machines.
12. Discuss care and cleaning of drilling machines.
13. Select from a list factors that affect cutting speeds for drilling operations.
14. Determine rpm for drilling using drill speed chart.
15. Calculate drill speeds using rpm formula.
16. Demonstrate the ability to:
    a. Drill and ream holes to layout.
    b. Countersink and counterbore holes to specification.
    c. Tap holes using the drill press.

DRILL PRESS
UNIT II

SUGGESTED ACTIVITIES

I. Suggested activities for instructor

  A. Provide students with objective sheet.

  B. Provide students with information and assignment sheets.

  C. Make transparencies.

  D. Discuss unit and specific objectives.

  E. Demonstrate and discuss procedures outlined in job sheets.

  F. Discuss importance of using correct rpm.

  G. Review cutting speeds (CS) of materials in Materials and Cutting Fluids unit.

  H. Demonstrate safety procedures for drill press work.

  I. Give test.

  J. Reteach and retest if necessary.

II. Instructional materials

  A. Objective sheet

  B. Information sheet

  C. Transparency masters

    1. TM #1--Types of Drill Presses

    2. TM #2--Types of Drill Presses Continued

    3. TM #3--Parts of the Drill Press

    4. TM #4--Drill Press Operations

    5. TM #5--Cutting Tools

    6. TM #6--Cutting Tools Continued

    7. TM #7--Drill Press Spindle Drives

    8. TM #8--Workholding and Set-Up Devices

   9. TM #9--Workholding and Set-Up Devices Continued
   10. TM #10--Devices for Holding Cutting Tools
   11. TM #11--Coolant Applications

D. Assignment sheets

   1. Assignment Sheet #1--Identify Drill Press Operations
   2. Assignment Sheet #2--Write Safety Rules for Safe Use of Drilling Machines
   3. Assignment Sheet #3--Calculate Speeds and Feeds for Drilling Operations

E. Answers to assignment sheets

F. Job sheets with attached blueprints

   1. Job Sheet #1--Drill and Ream Holes to Layout
   2. Job Sheet #2--Countersink and Counterbore Holes to Specification
   3. Job Sheet #3--Tap Holes Using the Drill Press

G. Test

H. Answers to test

III. References

A. Kibbe, Richard R.; Neely, John E.; Meyer, Roland; and White, Warren T. *Machine Tool Practices*. New York: John Wiley and Sons, 1979.

B. Krar, S.F.; Oswald, J.W.; and St. Amand, J.E. *Technology of Machine Tools*. Toronto: McGraw-Hill Book Company of Canada, 1969.

C. Oberg, Erik, and Jones, F.D. *Machinery's Handbook*, 21st ed. New York: The Industrial Press, 1979.

DRILL PRESS
UNIT II

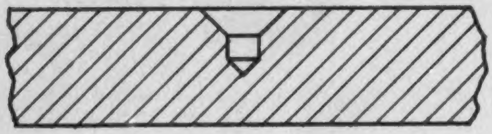
INFORMATION SHEET

I. Terms associated with drill press operations

A. Pilot hole--Small hole used to guide a drill of a larger size

(NOTE: The pilot hole is no larger than the web of the larger drill.)

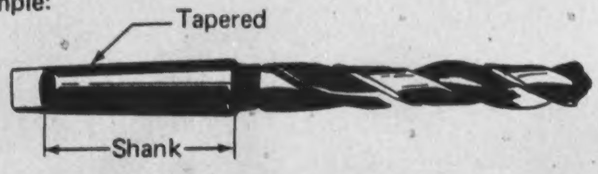
B. Center drill--Producing a small hole with a 60° taper at the top of the hole using a combination drill and countersink (center drill)



C. Taper shank--Tapered portion of a cutting tool that aligns the tool in the spindle or holder

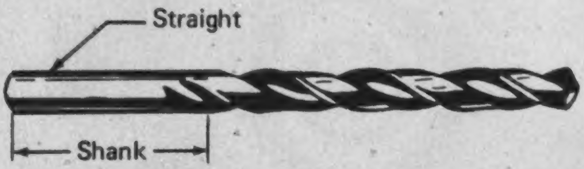
(NOTE: The taper shank cannot be held in a drill chuck.)

Example:



D. Straight shank--Straight portion of a cutting tool that aligns the tool in the holder

Example:



E. Number drills--Drills that are graduated from number 80 (.0135") to number 1 (.228"); sometimes referred to as wire gage size drills

INFORMATION SHEET

F. Letter drills--Drills that are graduated from A (.234") to Z (.413")

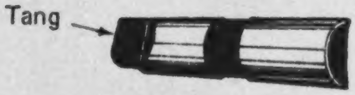
G. Metric drills--Drills that are graduated from .35mm to 25mm and larger

H. Fractional drills--Drills that are graduated by fractions of inches from 1/64" to 1" and larger

(NOTE: The decimal equivalents of the number, letter, and metric drills are in between the fractional sizes.)

I. Tang--Flats or tongue machined on the end of a tapered shank to prevent the taper from rotating in the mating part

Example:



J. Feed pressure--The amount of force put on a tool in the downward direction, expressed in feed per inch per revolution of the tool

II. Types of drill presses (Transparencies 1 and 2)

A. Sensitive bench drill press

B. Upright drill press

C. Radial arm drill press

D. Gang drill press

E. Multispindle drilling, boring, and tapping machine

F. Bench turret drill press

G. Numerical control turret drilling and tapping machine

III. Function of a drill press--To produce round holes in material by using twist drills and other types of cutting tools

IV. Major parts of a drill press (Transparency 3)

A. Speed selector

B. Head

INFORMATION SHEET

C. Switch

D. Spindle lock

E. Depth gage

F. Spindle

G. Coolant nozzle

H. Table

I. Table stop collar

J. Base

K. Coolant pump

L. Table locking bolts

M. Table elevating crank

N. Column

O. Manual feed lever

P. Feed drive

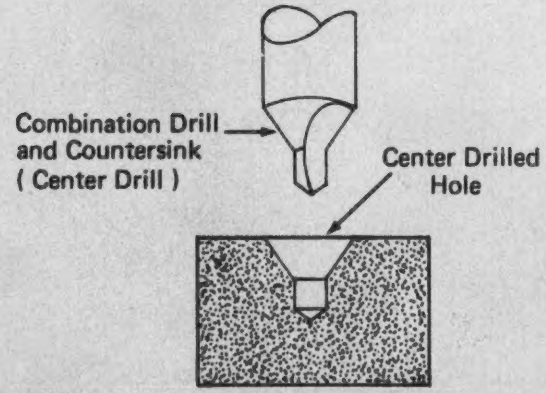
Q. Depth stop

R. Motor

S. Belt guard

V. Operations performed on drill press (Transparency 4, Assignment Sheet #1)

A. Center drilling--Making a hole with a tapered top so the drill will start in location desired


Combination Drill and Countersink (Center Drill)
Center Drilled Hole

INFORMATION SHEET

B. Drilling--Producing a hole of a given size and depth

C. Boring--Enlarging an existing hole to a given size and depth

D. Counterboring--Enlarging a hole with a flat bottom for a screw head to set in below the surface

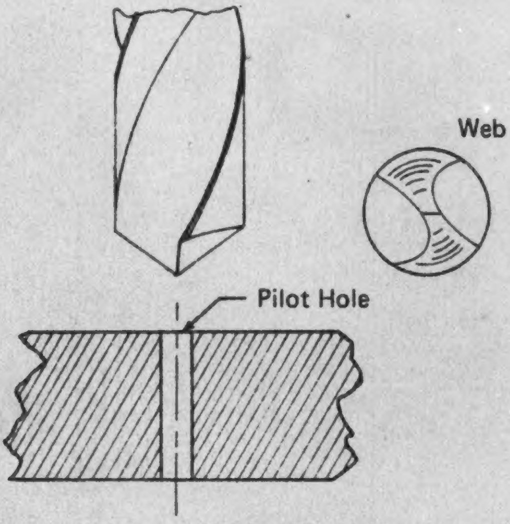
E. Countersinking--Producing a tapered surface in a hole so a flat head screw will be flush with the top surface of the part

F. Tapping--Producing a screw thread in a hole that has been drilled to a specific size

G. Drilling a pilot hole--Producing a small hole that is used to guide a larger drill and reduce the feed pressure of the larger drill

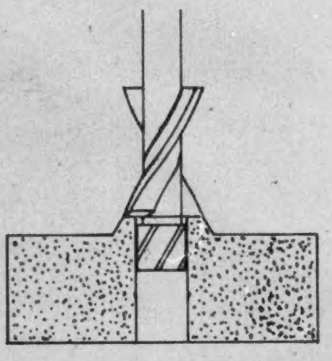
(NOTE: The pilot hole is drilled no larger than the web of the larger drill.)

Example:



INFORMATION SHEET

H. Spot facing--Making a flat surface so a bolt head or nut will seat properly



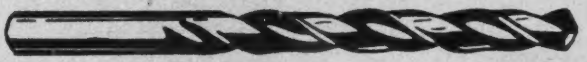
I. Reaming--Enlarging a hole a small amount to make it true to size

J. Chamfering--Making a small angular surface at the top of a hole

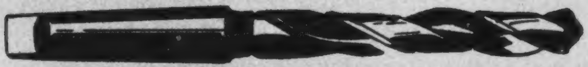
VI. Cutting tools used for drill press operations (Transparencies 5 and 6)

A. Twist drills

1. Straight shank

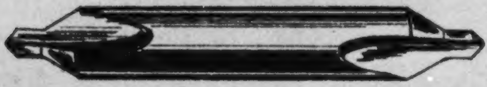


2. Tapered shank



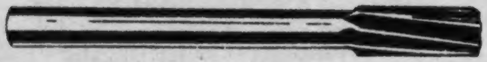
INFORMATION SHEET

B. Center drill (combination drill and countersink)

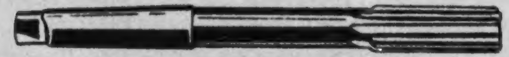


C. Reamers

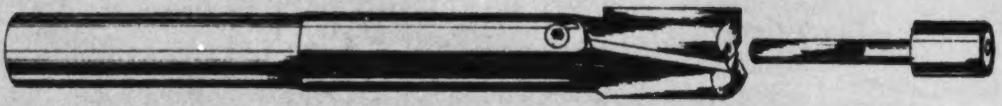
1. Straight shank



2. Tapered shank



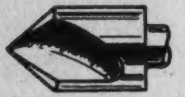
D. Counterbore or spot facer with pilot



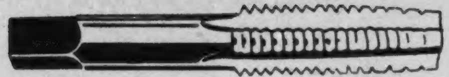
INFORMATION SHEET

E. Countersink

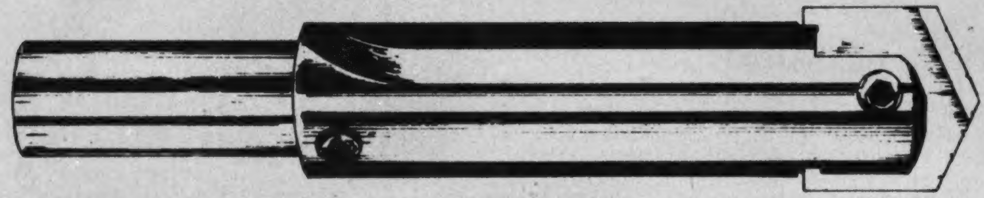
(NOTE: Countersinks come with different angles.)



F. Tap



G. Spade drill



VII. Types of drill press spindle drives (Transparency 7)

A. Cone pulley drive--Found on most sensitive type bench and floor mounted machines; speeds are obtained by changing belt position

B. Variable speed drive--Found on sensitive type floor mounted machines; speeds are obtained by turning the speed selector

C. Gear head drive--Found on floor mounted machines like box column and radial drill presses; speeds are obtained by changing gears

INFORMATION SHEET

VIII. Workholding and set-up devices used in drill press operations (Transparencies 8 and 9)

(NOTE: All workholding devices must be secured to the table with clamps or bolts.)

A. Angle vise

B. Parallel clamp

C. C-clamp

D. Drill fixture

E. Strap clamp

F. T-bolt

G. Angle plate

H. V-block

I. Vise

J. Parallels

K. Screw jack

L. Step block

IX. Attachments and accessories used with drill presses (Transparency 10)

A. Tapping attachment

B. Drill chuck

C. Floating chuck

D. Morse taper shank adapter sleeve

E. Steel sockets

F. Drill drift

X. Methods of applying coolants (Transparency 11)

A. Oil can

B. Spray mist

C. Flood

D. Brush

INFORMATION SHEET

XI. Rules for safe use of drilling machines (Assignment Sheet #2)

A. Eyes--Always wear safety glasses to protect your eyes from chips

B. Clothing--Always wear tight-fitting clothes to prevent them from being caught in revolving parts

C. Guards--Never operate the drilling machine with guards removed

D. Chuck key or drill drift--Should be removed immediately after using; never leave key in drill chuck or drift in spindle because if machine is turned on they will be thrown and possibly cause injury

E. Watches and rings--Remove before operating drill press or any machine to prevent possible accidents

F. Chips--Remove with a brush, never your hands

G. Rags--Should never be used while machine is running, and never left on the table of a running machine

H. Work–Should always be held in a vise or other workholding device that is secured to the table; never try to hold work with your hands

I. Feed pressure--Ease up when the drill is breaking through so it will not grab and leave a big burr

J. Drill chuck–Designed to hold straight shank drills and tools; should never be used to hold tools with tapered shanks

K. Drill drift--The only tool that should be used to remove tapered shank tools from spindles or sleeves

L. Machine in motion--Never clean or make adjustments while machine is running

M. Hands--Never pick up a drill, work, or any tool that you have been using as it is hot and will burn; use a rag

N. Table--Should be kept clean and free of tools to eliminate accidents and possible damage to tools

O. Spindle tapers--Should never be cleaned when spindle is being turned by power

P. Deep holes--Interrupt the feed occasionally to break up chips and clear the drill

Q. Chucks and other tools with tapered shanks--Always place a board on the table under tool so when you break the taper with the drill drift it will not fall and damage the tool or table of the drill press

R. Floor--Keep work area clean and free of slippery materials or chips to prevent accidents

INFORMATION SHEET

S. Drill press--Clean machine and floor after using drill press

T. Tools--Clean oil or coolant from drills and other tools and put them up in the proper place

U. Hair--Long hair must be secured under a hat, in a hair net, or tied back to prevent it from being caught by rotating parts of the drill press

(NOTE: Short hair is preferred.)

XII. Care and cleaning of drilling machines

A. Lubrication--Check all oil levels for proper levels before using

B. Belts--Check drive belts for proper tightness

C. Variable speed drives--Never crank the speed selector when spindle is not turning

D. Gear drives--Never shift gears when spindle is turning; shut off machine

E. Chips--Clean chips off table with a brush

F. Tools--Never use a dull tool since it causes more friction and will ruin the tool

XIII. Factors that affect cutting speeds for drilling operations

A. Drill size

B. Drill material

C. Type of material to be drilled

Examples: Carbide-tipped tools will turn approximately two times faster than tools made of high speed steel; reamers turn at 1/2 drill speed, counterbores and countersinks turn at 1/3 drill speed

XIV. Determining rpm for drilling (Assignment Sheet #3)

A. Find the material in one of the headings across top of chart

B. Move down the column marked drill diameter (inches) to the size of drill

INFORMATION SHEET

C. The intersection of the two columns is the rpm for that size of drill and that kind of material

Example: Material--Mild steel

Drill size–1/4"

rpm--1528

Drilling Speeds for High-speed Steel Drills								
Drill Diam., Inches	Bronze, Brass, 300 Feet	Cast Iron Annealed 150 Feet	Cast Iron Hard 70 Feet	Mild Steel 100 Feet	Drop Forgings 60 Feet	Mal. Iron 90 Feet	Tool Steel 50 Feet	Cast Steel, 40 Feet
	Revolutions Per Minute							
1/16	....	9170	4278	6111	3669	....	3056	2440
1/8	9170	4584	2139	3056	1830	2745	1528	1220
3/16	6112	3056	1426	2037	1210	1830	1019	807
1/4	4585	2292	1070	1528	915	1375	764	610
5/16	3660	1833	856	1222	732	1138	611	490
3/8	3056	1528	713	1019	610	915	510	407
7/16	2614	1310	611	873	522	784	437	348
1/2	2287	1146	535	764	458	688	382	305
5/8	1830	917	428	611	366	569	306	245
3/4	1525	764	357	509	305	458	255	203
7/8	1307	655	306	436	261	392	218	174
1	1143	573	267	382	229	349	191	153
1 1/4	915	458	214	306	183	275	153	122
1 1/2	762	382	178	255	153	212	127	102
1 3/4	654	327	153	218	131	196	109	87
2	571	287	134	191	115	172	95	77

INFORMATION SHEET

XV. Calculation of drill speeds using rpm formula (Assignment Sheet #3)

(NOTE: Tools should turn at the proper rpm to cut effectively. This modified formula gives a good approximation.)

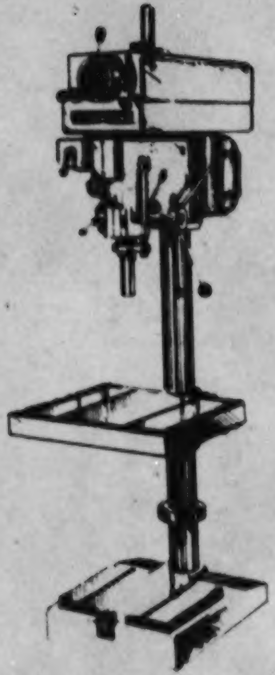
$$\text{Formula} = \frac{4 \times \text{Cutting speed of material}}{\text{Diameter of drill}} = \text{rpm}$$

Example:

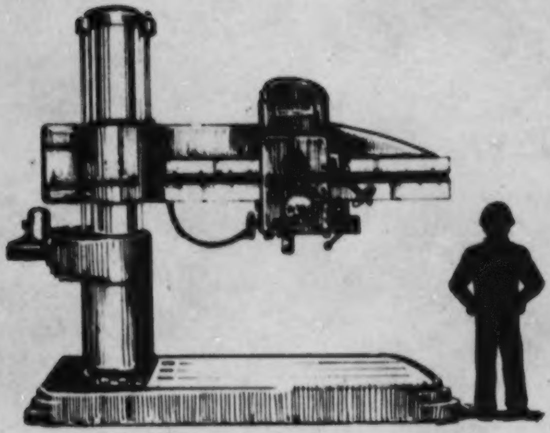
$$\frac{4 \times 100 \text{ (Cutting speed of mild steel)}}{.75 \text{ (Diameter of drill) in inches}} = 533.3$$

(NOTE: Feed is based on rpm and will vary with size of drill.)

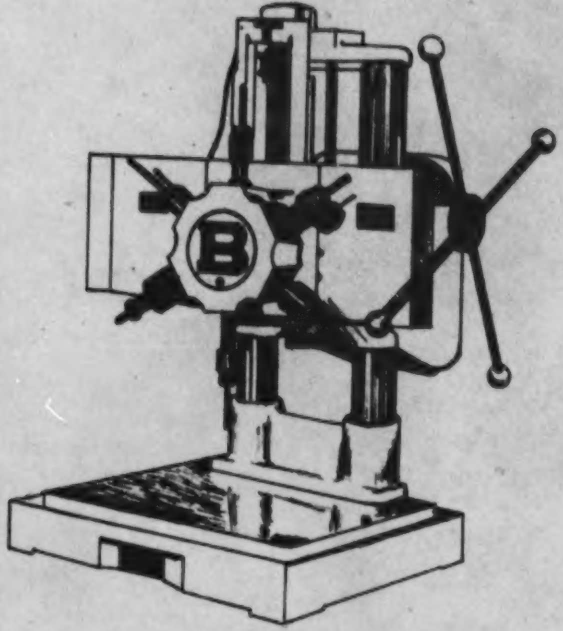
Types of Drill Presses



Upright Drill Press



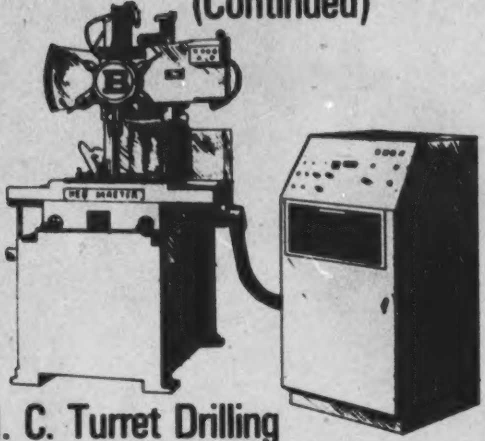
Radial Arm Drill Press



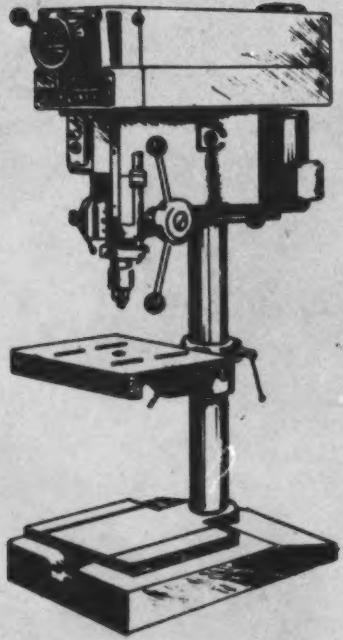
Bench Turret Drill Press

Types of Drill Presses

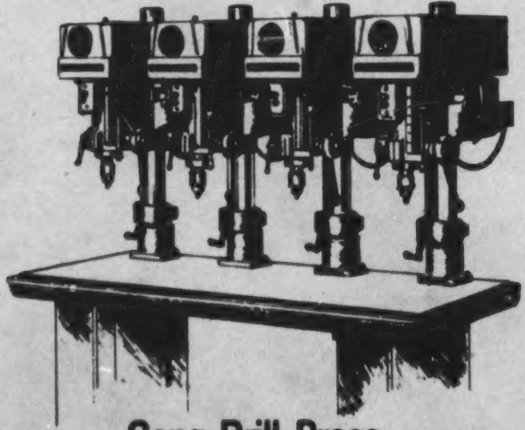
(Continued)



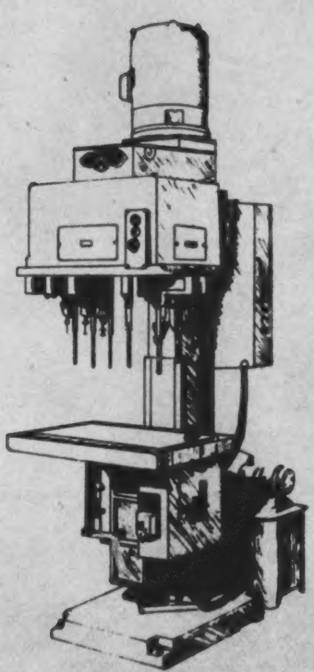
N. C. Turret Drilling
and Tapping Machine



Sensitive
Bench Drill Press

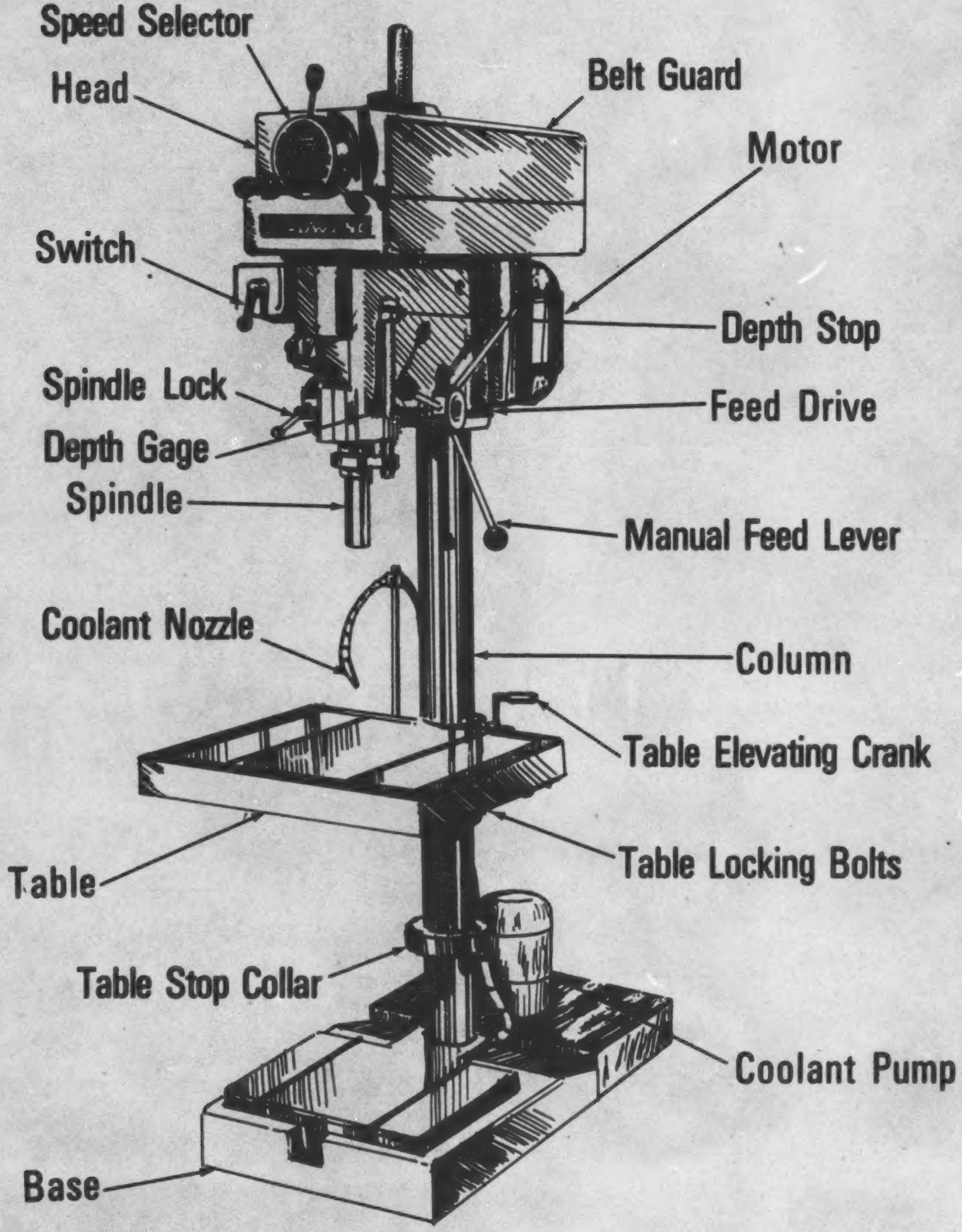


Gang Drill Press



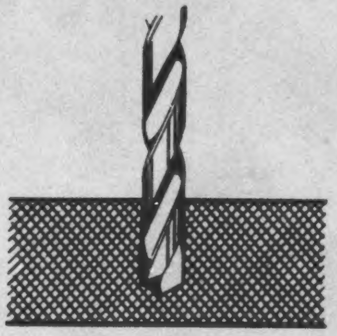
Multi Spindle Drilling,
Boring and Tapping Machine

Parts of the Drill Press

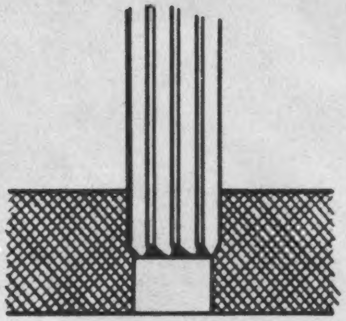

Speed Selector
Head
Belt Guard
Motor
Switch
Depth Stop
Spindle Lock
Feed Drive
Depth Gage
Spindle
Manual Feed Lever
Coolant Nozzle
Column
Table Elevating Crank
Table
Table Locking Bolts
Table Stop Collar
Coolant Pump
Base

Drill Press Operations

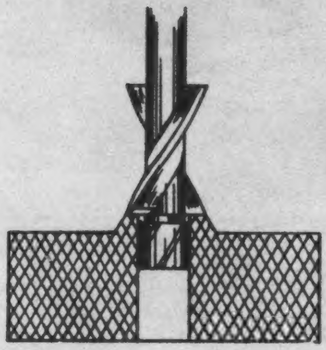
Drilling



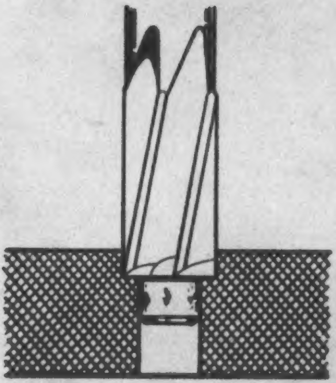
Reaming



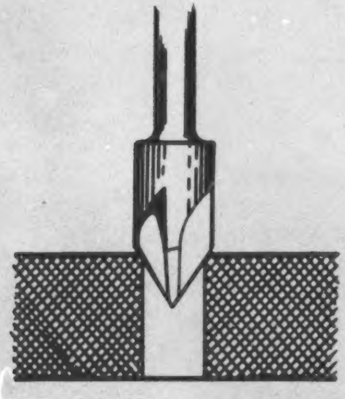
Spot Facing



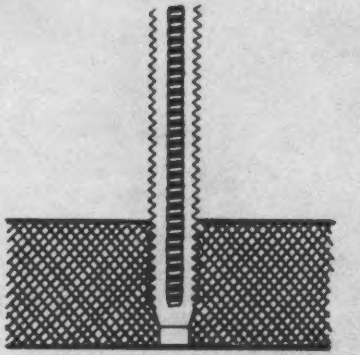
Counterboring



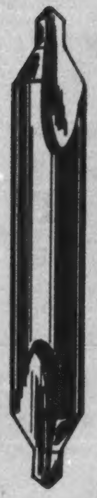
Chamfering



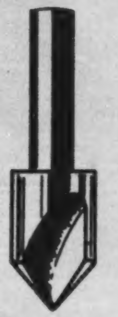
Tapping



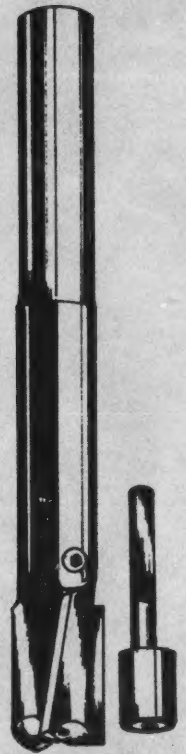
Cutting Tools



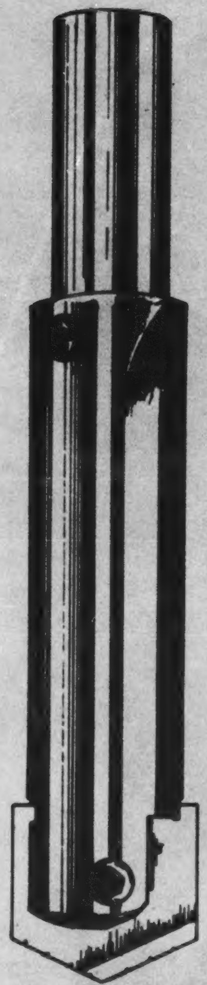
(Center Drill)
Combination Drill
and Countersink



Countersink



Counterbore or
Spot facer and Pilot

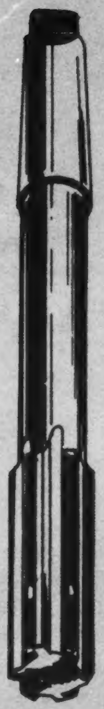


Spade Drill

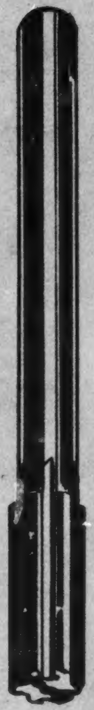
Cutting Tools

(Continued)

Reamers

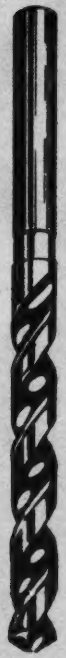


Tapered Shank

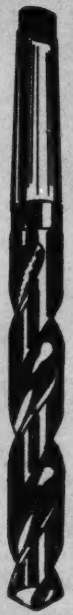


Straight Shank

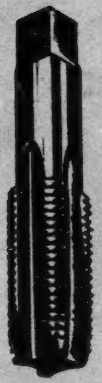
Twist Drills



Straight Shank

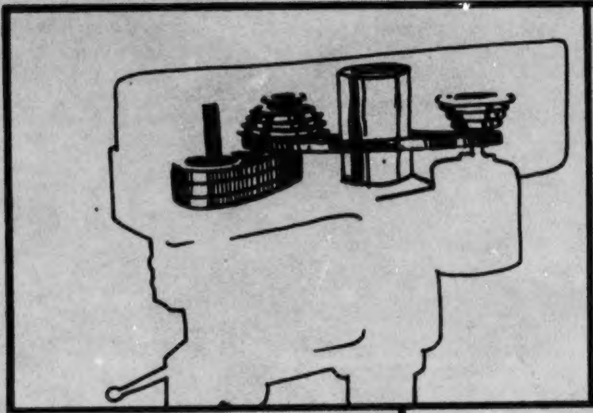


Tapered Shank

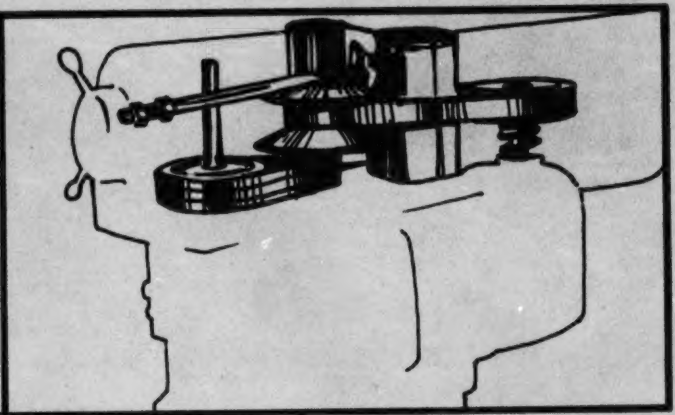


Tap

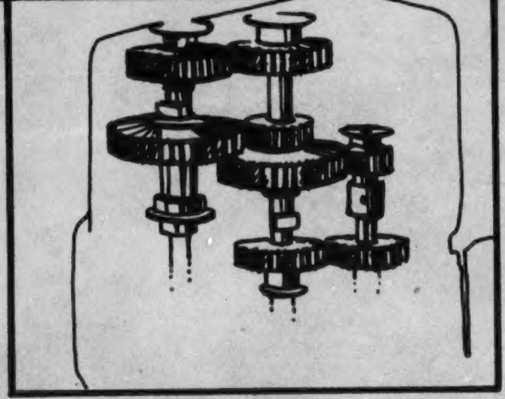
Drill Press Spindle Drives



Cone Pulley Drive

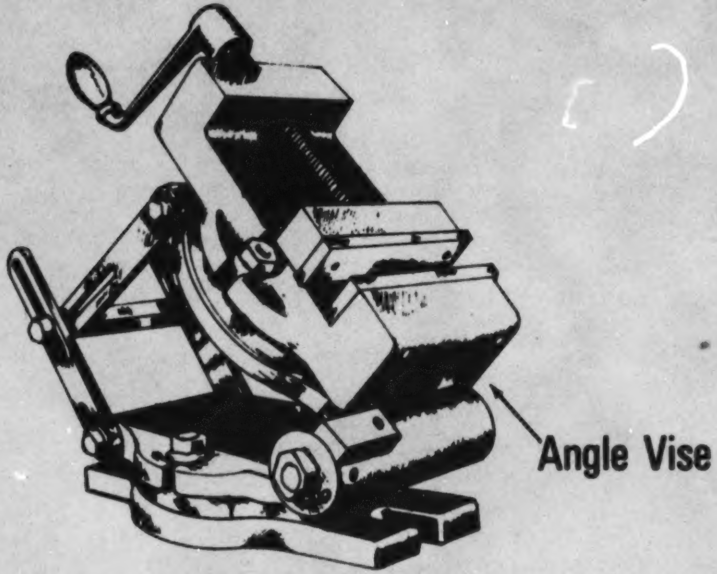


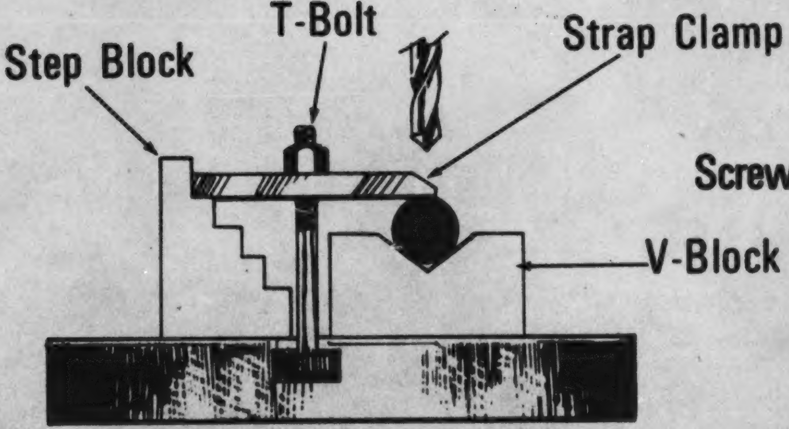
Variable Speed V-Belt

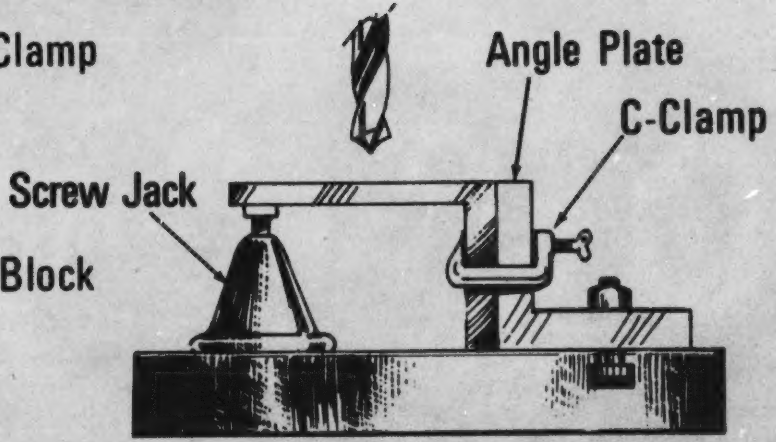


Gear Head Drive

Workholding and Set-up Devices

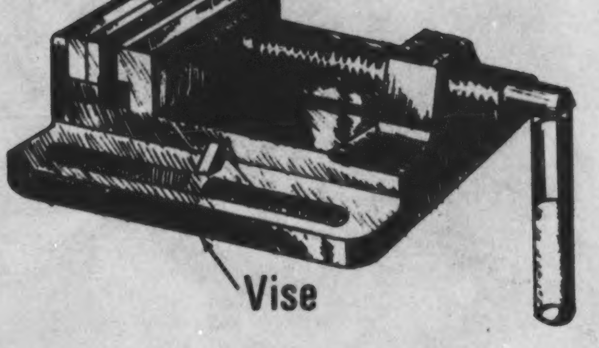


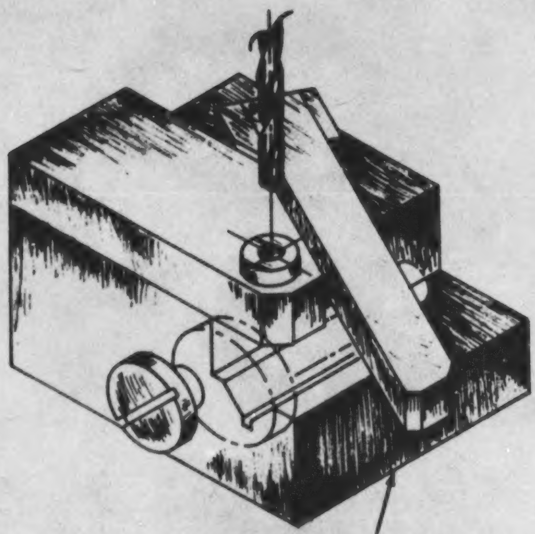

Step Block
T-Bolt
Strap Clamp
V-Block

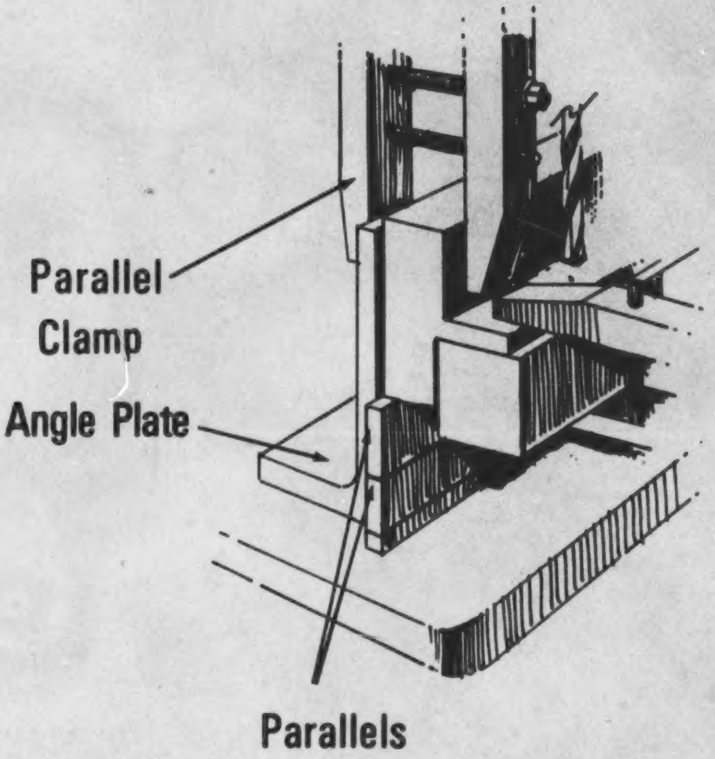

Angle Plate
C-Clamp
Screw Jack

Workholding and Set-up Devices

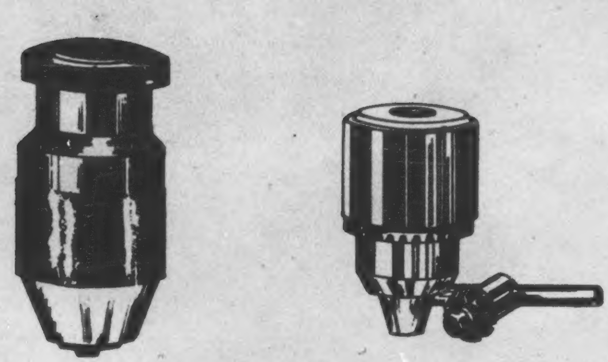
(Continued)



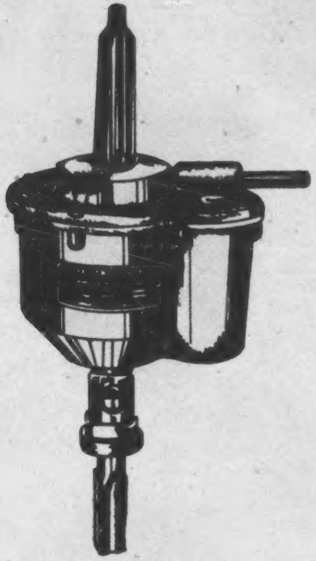

Drill Fixture


Parallel Clamp
Angle Plate
Parallels

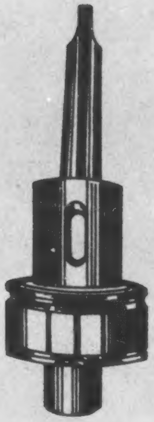
Devices for Holding Cutting Tools



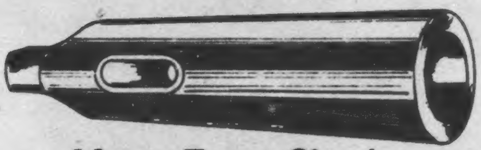
Drill Chucks



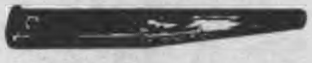
Tapping Attachment



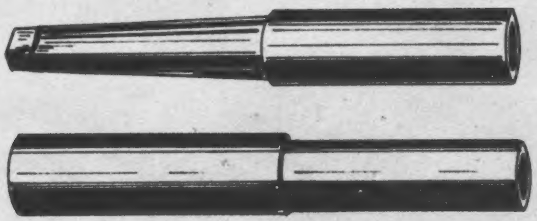
Floating Chuck



Morse Taper Shank Adapter Sleeve

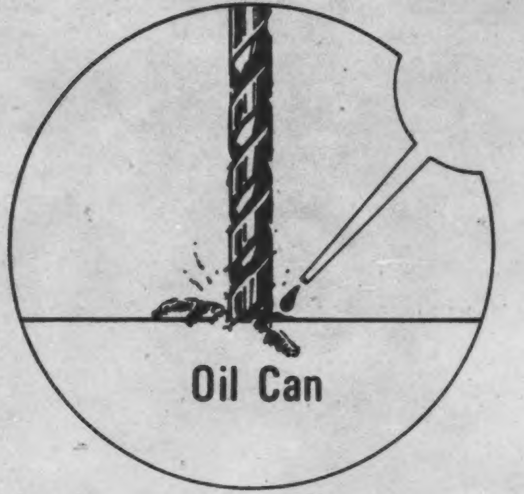


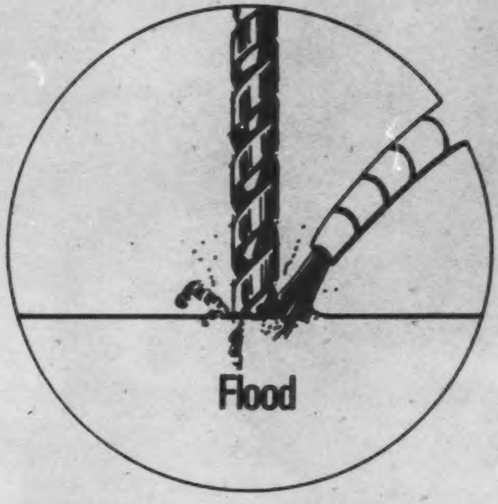
Drill Drift

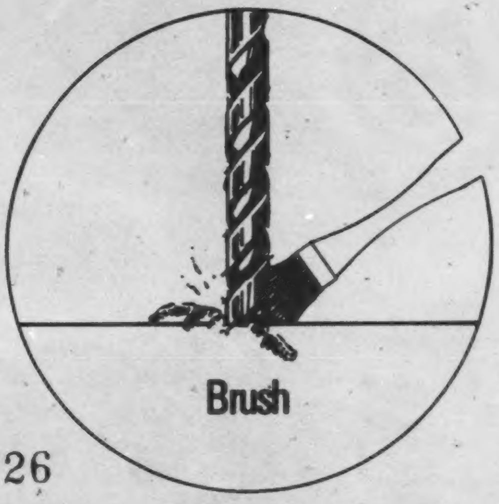


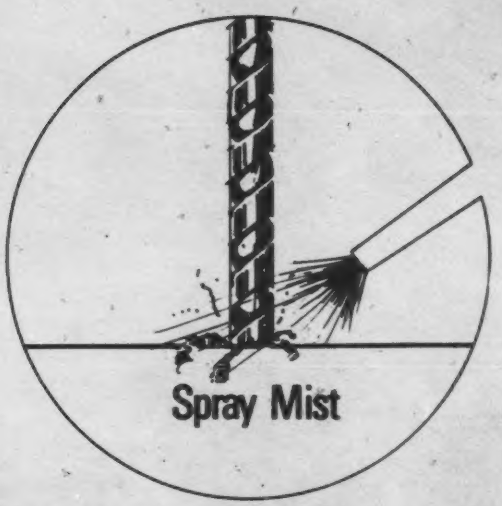
Steel Sockets

Coolant Applications


Oil Can


Flood


Brush


Spray Mist

DRILL PRESS
UNIT II

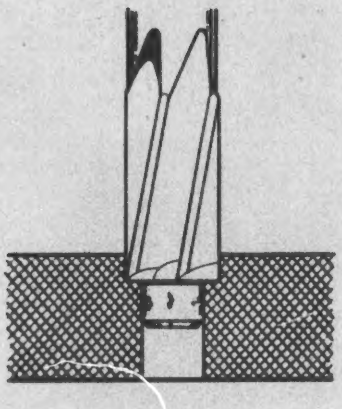
ASSIGNMENT SHEET #1--IDENTIFY DRILL PRESS OPERATIONS

NAME________________________________ SCORE ________________

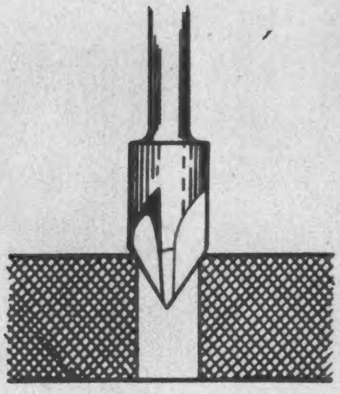
Drilling operations are important because parts have already had work performed on them when they are ready to be drilled. Care must be taken because mistakes become very costly.

Identify the drilling operations pictured below and on the next page. Write the correct names in the blanks.

Center drilling
Counterboring
Drilling
Spot facing
Tapping
Countersinking
Reaming
Chamfering
Pilot hole drilling

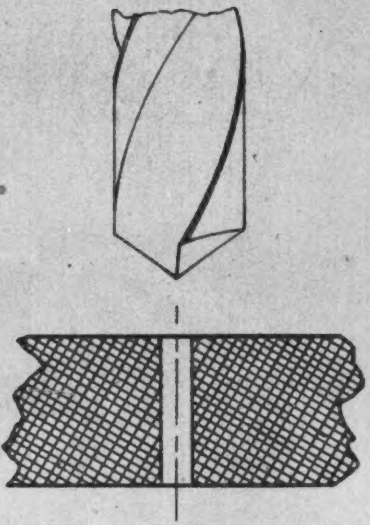


1. ______________________________

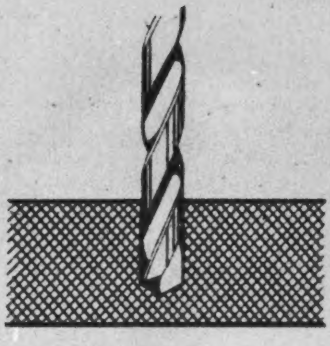


2. ______________________________

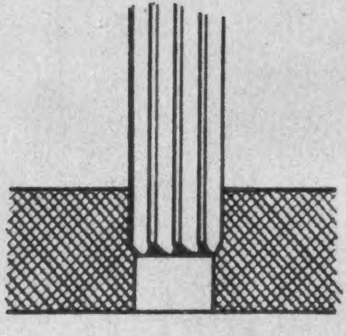
ASSIGNMENT SHEET #1



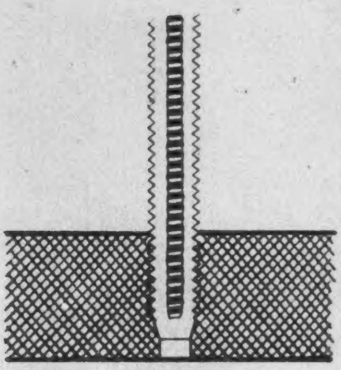
3. ____________________



4. ____________________

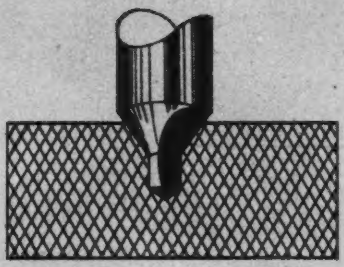


5. ____________________

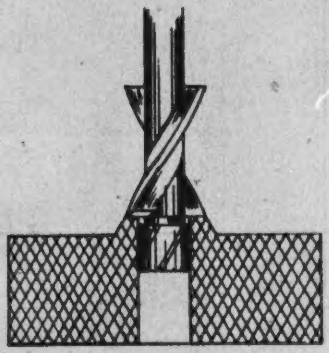


6. ____________________

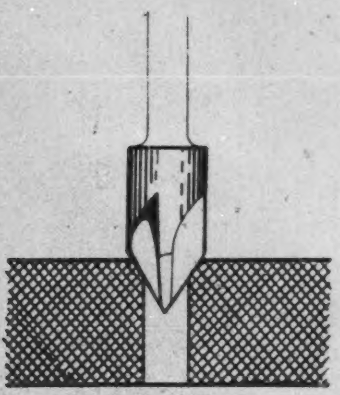
ASSIGNMENT SHEET #1



7. ______________________________



8. ______________________________



9. ______________________________

DRILL PRESS
UNIT II

ASSIGNMENT SHEET #2--WRITE SAFETY RULES FOR SAFE USE OF DRILLING MACHINES

NAME________________________________ SCORE ____________________

Safety and safe operation are words that industry uses daily, because lack of safety or safe working conditions can result in accidents and lost time due to injuries.

(NOTE: The minimum acceptable score is 100 percent accuracy.)

Complete each of the following safety rules.

1. Watches and rings-- ____
____
____
2. Eyes-- ____
____
3. Hands-- ____
____
____
4. Chucks and other tools with tapered shanks-- ________________________
____
____
____
5. Chips-- ____
____
____
6. Clothing-- ____
____
____
7. Deep holes-- ____
____

ASSIGNMENT SHEET #2

8. Work-- ______________________________

9. Guards-- ______________________________

10. Table-- ______________________________

11. Feed pressure-- ______________________________

12. Chuck key or drill drift-- ______________________________

13. Tools-- ______________________________

14. Drill chuck-- ______________________________

15. Floor-- ______________________________

16. Drill drift-- ______________________________

ASSIGNMENT SHEET #2

17. Drill press-- ____

____

____

18. Machine in motion-- ____

____

____

19. Rags-- ____

____

20. Spindle tapers-- ____

____

____

21. Hair-- ____

____

____

DRILL PRESS
UNIT II

ASSIGNMENT SHEET #3--CALCULATE SPEEDS AND FEEDS FOR DRILLING OPERATIONS

NAME______________________________ SCORE ________________

The speed and feed must be correct if the tool is to do an accurate and efficient job. Too often tools are damaged from improper feeds and speeds.

Answer each of the following questions.

1. Name three reasons drilling speed will vary.

   a. ____

   b. ____

   c. ____

2. Carbide and carbide-tipped tools will turn__________times faster than high speed steel tools.

3. Reamers should turn at__________the speed of a drill.

4. Calculate the rpm of a 3/4" H.S.S. drill if you are drilling mild steel plates 1" thick. Use 120 as the cutting speed (CS). Show your work.

   a. Calculated rpm ____________________

   b. If the drill press is a step pulley drive having 5 speeds: 260, 530, 1060, 1860, and 3600, what speed would you use? ____________________

ASSIGNMENT SHEET #3

5. Calculate the rpm of a 1/2" drill (H.S.S.) if you are to drill 5 holes in an aluminum plate 1 1/2" thick. Use 250 as the CS for the aluminum. Show your work.

   a. Calculated rpm ______________________

   b. If the only rpms available on the drill press are 260, 530, 1060, 1860, and 3600, which would you use? ______________________

6. Find the correct rpm and feed rate for the following drills. Use the chart on the next page.

(NOTE: All drills are H.S.S.)

Drill Size	Material to be Drilled	Feed Rate Inches/Rev.	Speed rpm
1/8"	Tool Steel		
3/8"	Mild Steel		
1/2"	Brass		
3/4"	Cast Steel		
1 1/4"	Bronze		

ASSIGNMENT SHEET #3

High Speed Steel Drills									
Size of Drill	Feed per Rev.	Bronze, Brass, 300 Feet	Cast Iron, An-nealed, 170 Feet	Cast Iron, Hard, 80 Feet	Mild Steel 120 Feet	Drop Forg., 60 Feet	Mal. Iron, 90 Feet	Tool Steel, 60 Feet	Cast Steel, 40 Feet
Ins.	Ins.	rpm	rpm	rpm	rpm	rpm	rpm	rpm	rpm
1/16	0.003	....	....	4880	....	3660	....	3660	2440
1/8	0.004	....	5185	2440	3660	1830	2745	1830	1220
3/16	0.005	....	3456	1626	2440	1210	1830	1220	807
1/4	0.006	4575	2593	1220	1830	915	1375	915	610
5/16	0.007	3660	2074	976	1464	732	1138	732	490
3/8	0.008	3050	1728	813	1220	610	915	610	407
7/16	0.009	2614	1482	698	1046	522	784	522	348
1/2	0.010	2287	1296	610	915	458	636	458	305
5/8	0.011	1830	1037	488	732	366	569	366	245
3/4	0.012	1525	864	407	610	305	458	305	203
7/8	0.013	1307	741	349	523	261	392	261	174
1	0.014	1143	648	305	458	229	349	229	153
1 1/4	0.016	915	519	244	366	183	275	183	122
1 1/2	0.016	762	432	204	305	153	212	153	102
1 3/4	0.016	654	371	175	262	131	196	131	87
2	0.016	571	323	153	229	115	172	115	77

7. If a 1/2" H.S.S. drill is to turn at 458 rpm, a 1/2" H.S.S. reamer should turn at ______________ rpm.

8. If a 3/8" H.S.S. drill is to turn at 813 rpm, a 3/8" carbide drill should turn at ______________ rpm.

DRILL PRESS
UNIT II

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

1. Counterboring
2. Chamfering or countersinking
3. Pilot hole drilling
4. Drilling
5. Reaming
6. Tapping
7. Center drilling
8. Spot facing
9. Countersinking

Assignment Sheet #2

1. Remove before operating the drill press or any machine to prevent possible accidents
2. Always wear safety glasses to protect your eyes from chips
3. Never pick up a drill, work, or any tool that you have been using as it is hot and will burn; use a rag
4. Always place a board on the table under tool so when you break the taper with the drill drift it will not fall and damage the tool or table of the drill press
5. Remove with a brush, never your hands
6. Always wear tight-fitting clothes to prevent them from being caught in revolving parts
7. Interrupt the feed occasionally to break up chips and clear the drill
8. Should always be held in a vise or other workholding device that is secured to the table; never try to hold work with your hands
9. Never operate the drilling machine with guards removed
10. Should be kept clean and free of tools to eliminate accidents and possible damage to tools
11. Ease up when the drill is breaking through so it will not grab and leave a big burr
12. Should be removed immediately after using; never leave key in drill chuck or drift in spindle because if machine is turned on they will be thrown and possibly cause injury
13. Clean oil or coolant from drills and other tools and put them up in the proper place

14. Designed to hold straight shank drills and tools; should never be used to hold tools with tapered shanks

15. Keep work area clean and free of slippery materials or chips to prevent accidents

16. The only tool that should be used to remove tapered shank tools from spindles or sleeves

17. Clean machine and floor after using drill press

18. Never clean or make adjustments while machine is running

19. Should never be used while machine is running, and never left on the table of a running machine

20. Should never be cleaned when spindle is being turned by power

21. Long hair must be secured under a hat, in a hair net, or tied back to prevent it from being caught by rotating parts of the drill press

Assignment Sheet #3

1. a. Drill size
   b. Drill material
   c. Type of material to be drilled

2. 2

3. 1/2

4. a. 4 x 120/.75 = 640 rpm
   b. 530

5. a. 4 x 250/.5 = 2000 rpm
   b. 1860

6.

a.	.004	3660
b.	.008	1220
c.	.010	2287
d.	.012	203
e.	.016	915

7. 229

8. 1626

DRILL PRESS
UNIT II

JOB SHEET #1--DRILL AND REAM HOLES TO LAYOUT

I. Tools and equipment

- A. Drill press with 1/8" to 3/4" chuck and chuck key
- B. Brush
- C. Cutting fluid or oil
- D. Vise with T-bolts, nuts, and parallels
- E. Blueprint of tap and body drill gage (included with this job sheet)
- F. 1/8" letter stamps
- G. 3/16" x 3" x 4 3/4" steel plate
- H. Drills--#7, #3, F, I, Q, 5/16", 1/4", 23/54", 3/8", 25/64", 3/8", 27/64", and 1/2"
- I. Reamers--17/64"; 21/64"; 25/64"; 29/64"; and 33/64"
- J. 1/8" number set or etching pencil
- K. Combination drill and countersink #3
- L. Countersink 3/4" with 90° point
- M. Scribe and layout fluid
- N. Combination square set (12")
- O. File
- P. Center punch and ball peen hammer

II. Procedure

- A. Lay out center location of all holes to be drilled

  (NOTE: See blueprint included with this job sheet.)

- B. Center punch location of holes
- C. Set part in vise on parallels and tighten
- D. Fasten the center drill in chuck so only 1/2 its length extends beyond the chuck

  (CAUTION: Be sure to remove chuck key.)

JOB SHEET #1

E. Set speed to approximately 1,000 rpm

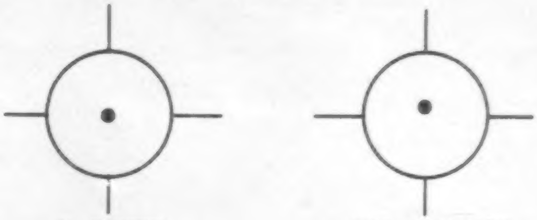
F. Locate the center punch mark in the part directly below the center drill point

G. Carefully feed the center drill until it just touches the work

H. Raise the center drill and examine the location

(NOTE: It should be in the center of the two lines. If not, you can move it with a center punch. See Figure 1.)

FIGURE 1


IN CENTER

NOT IN CENTER

I. When center drill is on center, apply cutting oil and continue to center drill to depth

(NOTE: The diameter of the center drilled hole should not exceed the diameter of the drill or be any deeper than the tapered portion of the center drill. See Figures 2-6.)

Examples:

FIGURE 2

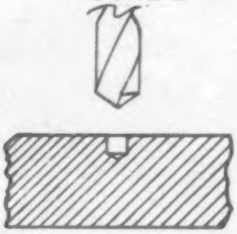

Not Deep Enough

FIGURE 3

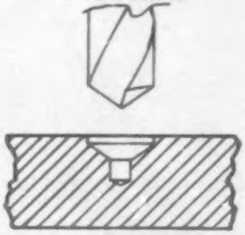

Too Deep

FIGURE 4

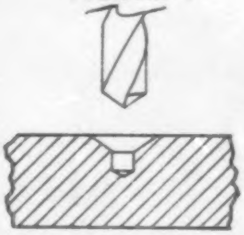

Too Deep for Drill Size

FIGURE 5

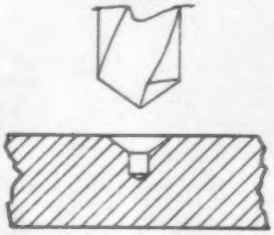
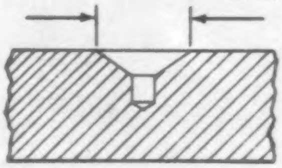

Just Right

FIGURE 6


Approxmately 2/3 Diameter of the Finished Hole

JOB SHEET #1

J. Continue to center drill all holes, repeating steps F through I

(NOTE: Body drill hole sizes are to be drilled 1/64" smaller and will be reamed to size.)

K. Remove center drill and secure the #7 drill in drill chuck

L. Set rpm for #7 drill and position the center of the drill in the center drilled hole and clamp or bolt vise to table of drill press

M. Apply cutting oil and feed the drill into the part

(CAUTION: Remember to ease up on the feed pressure as the drill breaks through the work.)

N. Remove #7 drill and secure #3 drill in drill chuck and repeat steps L and M

(NOTE: In some cases the rpm will be close enough that you will not need to change rpms; however, as your drills get larger you will need to change rpms.)

O. Continue this process and drill with a 1/4" drill (1/64" smaller than 17/64")

P. Remove the drill and insert the 17/64" reamer in drill chuck and tighten

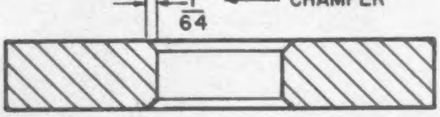
Q. Reduce the rpm to 1/2 that of the 1/4" drill

R. Apply oil to the reamer and ream the hole to size

S. Drill and ream all holes to correct size as per blueprint

T. Use countersink and chamfer all holes 1/64" on both sides (See Figure 7)

FIGURE 7



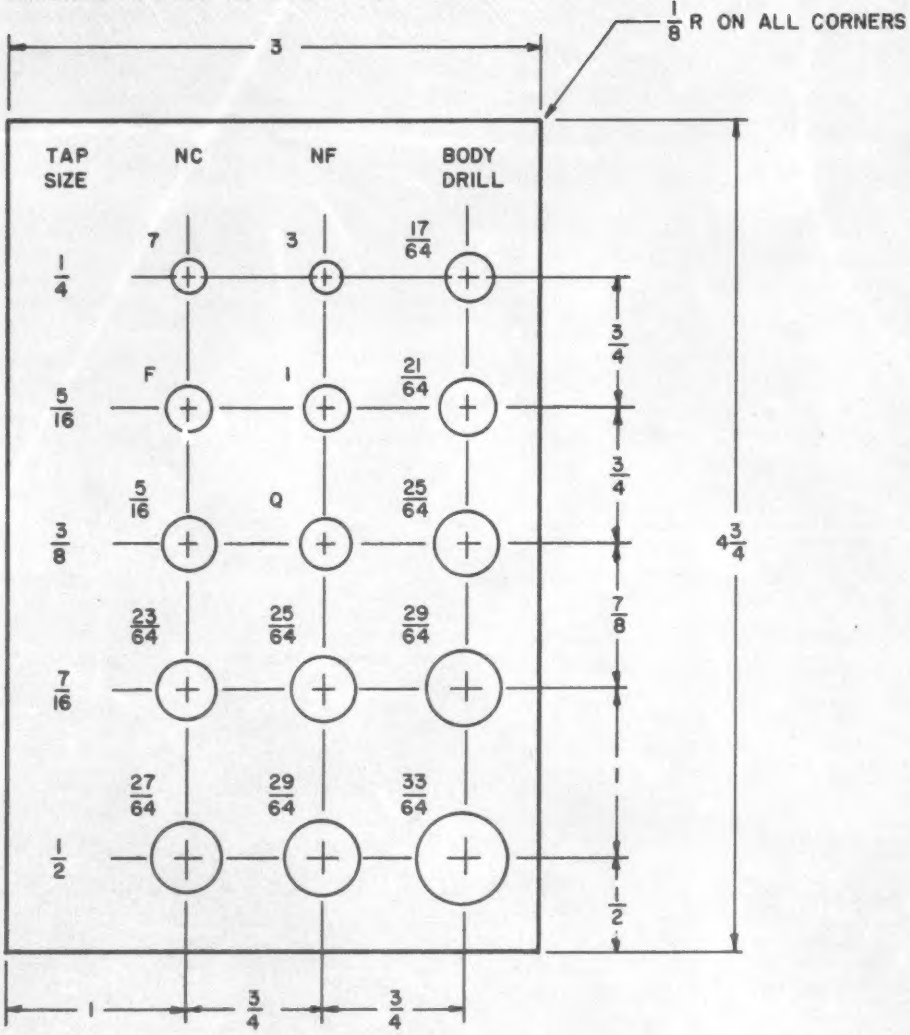
U. Use stamps or electric etching pencil and mark letters and fractional drill sizes of the different tap sizes and series

V. File 1/8" radius on all corners

W. Clean up machine and put all tools up in proper locations

JOB SHEET #1

MATERIAL 1018CRS 3/16 x 3 x 4 3/4


3
1/8 R ON ALL CORNERS
TAP SIZE
NC
NF
BODY DRILL
1/4
7
3
17/64
5/16
F
I
21/64
3/8
5/16
Q
25/64
7/16
23/64
25/64
29/64
1/2
27/64
29/64
33/64
3/4
3/4
7/8
1
1/2
4 3/4
1
3/4
3/4

TAP AND BODY DRILL GAGE

TOLERANCE

LOCATION OF ALL HOLES ± 1/64

SIZE OF ALL HOLES -.000
+.001

DRILL PRESS
UNIT II

JOB SHEET #2--COUNTERSINK AND COUNTERBORE HOLES TO SPECIFICATION

I. Tools and equipment

   A. Drill press with 1/2" chuck

   B. Vise and parallels

   C. 7/16" counterbore with 5/16" pilot

   D. Countersink 82° angle, 3/4" diameter

   E. 5/16-18 socket head cap screw

   F. #10-32 and 5/16-18 flat head screws

   G. Drills, 5/16" and #11

   H. Brush

   I. Cutting oil

   J. C-clamps or T-bolts and nuts

   K. 3/4" x 2" x 4" 1018 CRS stock

   L. Blueprint (included with this job sheet)

   M. Combination square and scribe

   N. Center punch and ball peen hammer

II. Procedure

   A. Lay out center locations of all holes where work is required

   (NOTE: See blueprint included with this job sheet.)

   B. Center punch locations for holes

   C. Set part in vise on parallels and secure

   D. Fasten the #11 drill in drill chuck and set the rpm at 1470; then drill the two holes

   E. Change drills and tighten the 5/16" drill in chuck; set rpm to 890 and drill the two 5/16" holes

   (CAUTION: If the drill press is variable drive, turn on the spindle before moving the speed selector.)

   F. Remove the drill and secure the countersink

JOB SHEET #2

G. Set the speed to 70 rpm

H. Bring the countersink down into the hole and set the graduated stop (Figures 1 and 2)

FIGURE 1

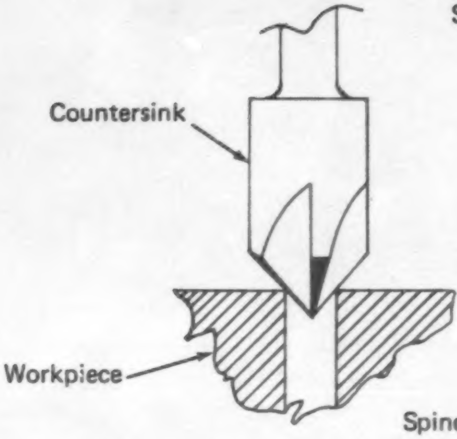
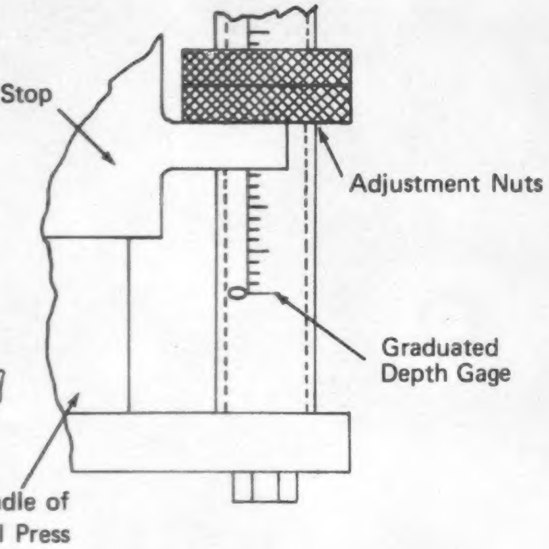

Countersink
Workpiece

FIGURE 2

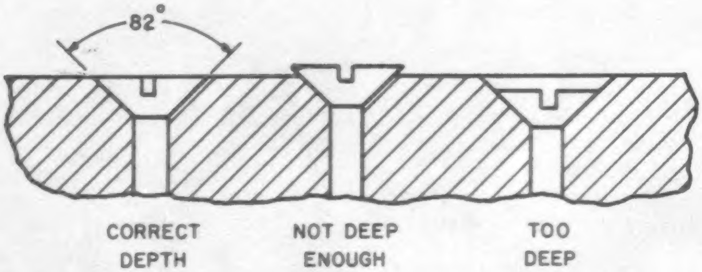

Stop
Adjustment Nuts
Graduated Depth Gage
Spindle of Drill Press

I. Tighten the spindle lock and back the adjusting nuts off the stop approximately .116"

J. Countersink the first hole

K. Check it with the #10 flat head screw for depth (Figure 3)

FIGURE 3

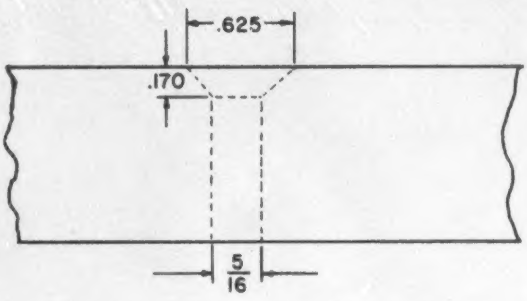

82°
CORRECT DEPTH
NOT DEEP ENOUGH
TOO DEEP

L. Adjust stop if necessary and countersink other hole

JOB SHEET #2

M. Repeat operations H through L and countersink hole for the 5/16" flat head screw (Figure 4)

FIGURE 4



N. Remove the countersink and put the counterbore in the drill chuck and tighten

O. Bring the counterbore down on the work and set the stop for 5/16" more

P. Make sure the pilot turns freely in the hole by turning the drill chuck by hand

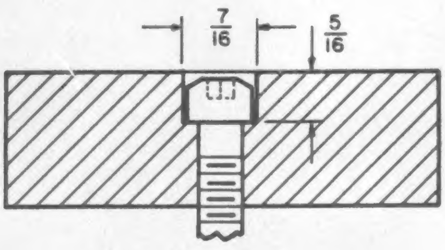
Q. Pull the pilot out of the hole; apply cutting oil to hole and counterbore

R. Start the machine and counterbore the hole

S. Check the depth of the counterbore with the 5/16" socket head cap screw

(NOTE: It should be slightly below the surface. See Figure 5.)

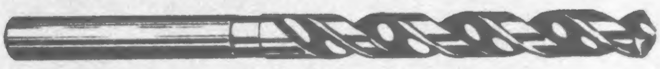
FIGURE 5



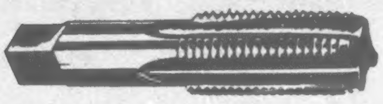
T. Remove the counterbore

U. Clean up the drill press and other tools and put them up in proper locations

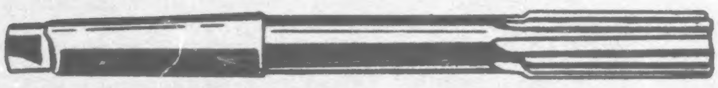
---



b. ______________________________

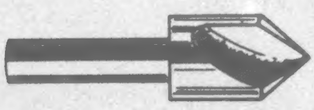


c. ______________________________



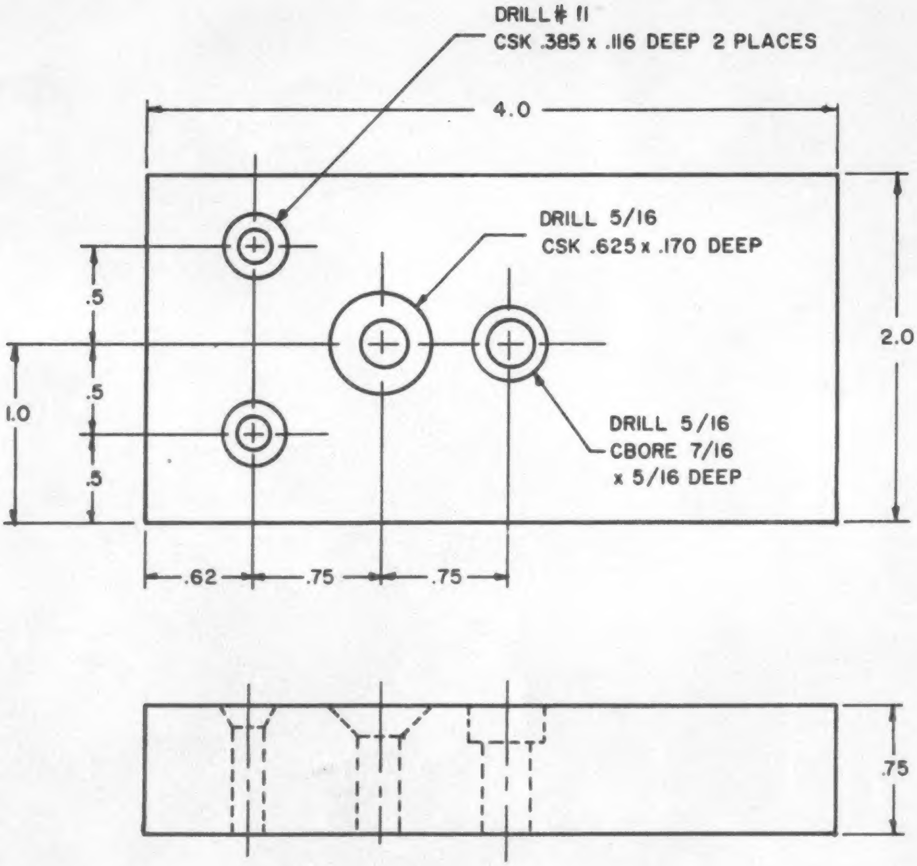
d. ______________________________

e. ______________________________



f. ______________________________

JOB SHEET #2


DRILL # 11
CSK .385 x .116 DEEP 2 PLACES
4.0
DRILL 5/16
CSK .625 x .170 DEEP
2.0
.5
.5
.5
1.0
DRILL 5/16
CBORE 7/16
x 5/16 DEEP
.62
.75
.75
.75

DRILL PRESS
UNIT II

JOB SHEET #3--TAP HOLES USING THE DRILL PRESS

I. Tools and equipment

- A. Drill press with chuck
- B. Centering tool
- C. Tap wrench
- D. 3/8-16 NC taper tap
- E. 5/16" drill
- F. Cutting oil
- G. Vise with parallels
- H. T-bolts and nuts
- I. Wrench
- J. Blueprint (included with this job sheet)
- K. Countersink (90°)
- L. Brush
- M. Center drill

II. Procedure #1

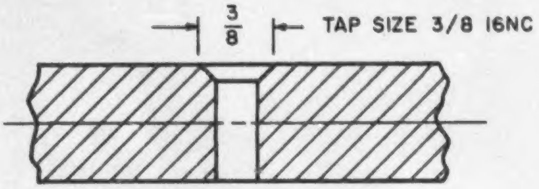
- A. Lay out location of hole to be tapped

  (NOTE: See attached blueprint.)
- B. Center drill holes
- C. Put the tap drill for the 3/8-16 NC tap in the drill chuck and secure
- D. Locate center of drill directly over center location of hole to be drilled
- E. Use the formula to set the correct rpm for drilling $(\frac{4 \times CS}{D})$
- F. Secure the vise
- G. Turn the switch on and drill the hole through the work
- H. Remove the drill, insert the countersink and secure in chuck
- I. Set rpm at 90

JOB SHEET #3

J. Chamfer the hole so the angular surface is diameter of the tap (Figure 1)

FIGURE 1



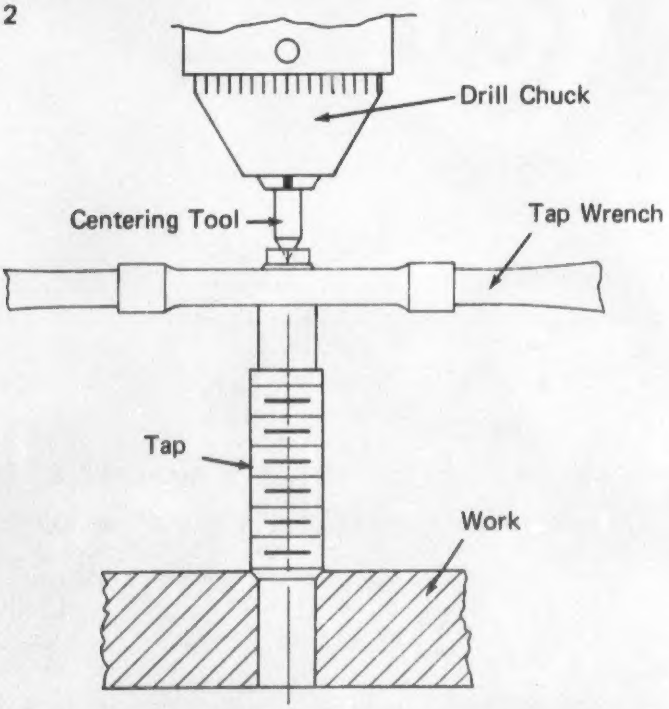
3/8
TAP SIZE 3/8 16NC

K. Remove the countersink, insert the center point in the chuck and secure

L. Install tap in tap wrench

M. Set the point of the tap in the hole and bring the spindle down until the centering tool is in the center of the tap (Figure 2)

FIGURE 2



Drill Chuck
Centering Tool
Tap Wrench
Tap
Work

N. Lock spindle clamp

O. Apply cutting oil to tap and hole

JOB SHEET #3

P. Gently turn the tap wrench to start thread approximately one turn

Q. Unlock the spindle and bring the center point down securely in center of tap and lock spindle again

R. Turn tap handle one more turn

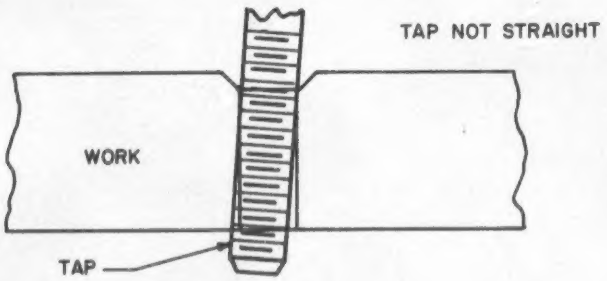
(NOTE: Repeat above procedure until tap has started and will stand.)

S. Remove work from the drill press vise and finish tapping in bench vise after thread is started

(NOTE: Apply more cutting oil and back the tap up 1/2 turn to break chip after each revolution.)

(CAUTION: Do not apply more pressure to one side of tap handle as it will result in a threaded hole that is not straight or a broken tap. See Figure 3.)

FIGURE 3



T. Clean machine and put up all tools

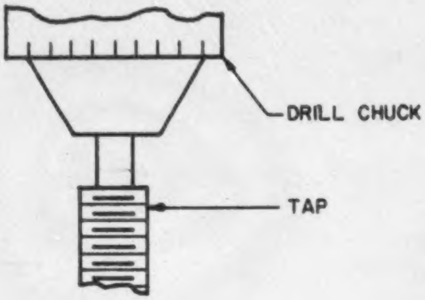
III. Procedure #2

A. Drill and chamfer as in the above procedure, steps B through J

JOB SHEET #3

B. Place chuck directly on tap since tap has no center hole for center point (Figure 4)

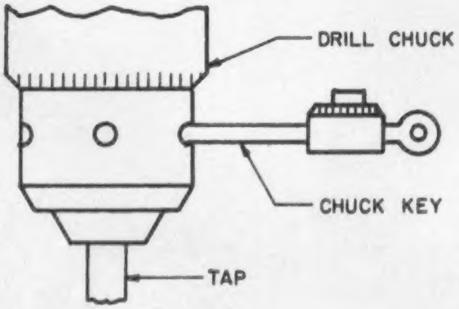
FIGURE 4



C. Bring the tap down into the hole and apply light downward pressure with feed handle

D. Insert the chuck key in the hole of the drill chuck and rotate the chuck by hand (Figure 5)

FIGURE 5



E. Apply cutting oil to tap and hole

F. When tap has started, release the feed handle and continue to tap approximately two revolutions

G. Grasp the feed handle with one hand and loosen the chuck until the tap is free; allow the spindle to withdraw slowly

(NOTE: Tapping can also be accomplished with the use of a tapping attachment mounted to the spindle of a drill press. Ask your instructor to explain.)

H. Remove part from drill press vise and clamp in bench vise

JOB SHEET #3

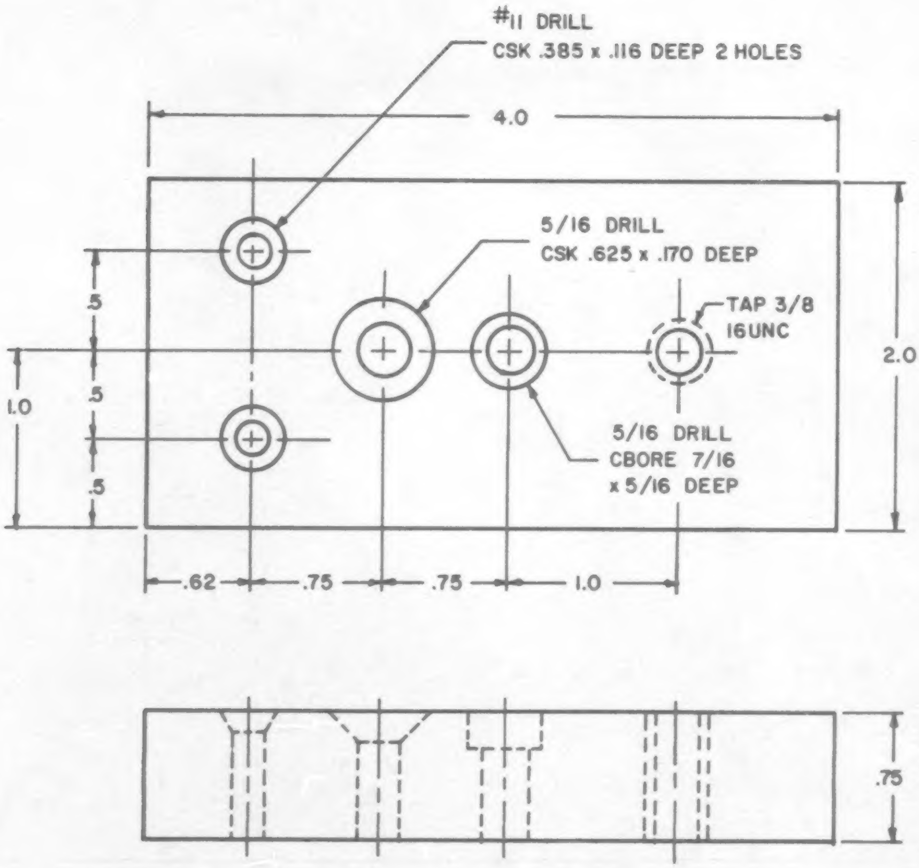
I. Put tap wrench carefully on tap and finish tapping hole

(NOTE: Apply more cutting oil and back the tap up 1/2 turn to break chip after each revolution.)

(CAUTION: Do not apply more pressure to one side of tap handle as it will result in a threaded hole that is not straight or a broken tap. See Figure 3.)

J. Clean machine and put up all tools

JOB SHEET #3


#11 DRILL
CSK .385 x .116 DEEP 2 HOLES
4.0
5/16 DRILL
CSK .625 x .170 DEEP
TAP 3/8
16UNC
2.0
.5
.5
.5
1.0
5/16 DRILL
CBORE 7/16
x 5/16 DEEP
.62
.75
.75
1.0
.75

DRILL PRESS
UNIT II

TEST

NAME________________________________ SCORE ____________________

1. Match terms associated with drill press operations to the correct definitions. Write the correct numbers in the blanks.

_____a. Tapered portion of a cutting tool that aligns the tool in the spindle or holder

_____b. Drills that are graduated from number 80 (.0135") to number 1 (.228"); sometimes referred to as wire gage size drills

_____c. The amount of force put on a tool in the downward direction, expressed in feed per inch per revolution of the tool

_____d. Drills that are graduated from .35mm to 25mm and larger

_____e. Straight portion of a cutting tool that aligns the tool in the holder

_____f. Flats or tongue machined on the end of a tapered shank to prevent the taper from rotating in the mating part

_____g. Small hole used to guide a drill of a larger size

_____h. Drills that are graduated from A (.234") to Z (.413")

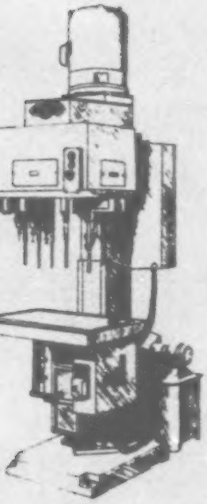
_____i. Producing a small hole with a 60° taper at the top of the hole using a combination drill and countersink (center drill)

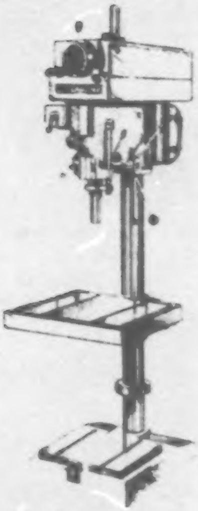
_____j. Drills that are graduated by fractions of inches from 1/64" to 1" and larger

1. Pilot hole
2. Center drilling
3. Taper shank
4. Straight shank
5. Number drills
6. Letter drills
7. Metric drills
8. Fractional drills
9. Tang
10. Feed pressure

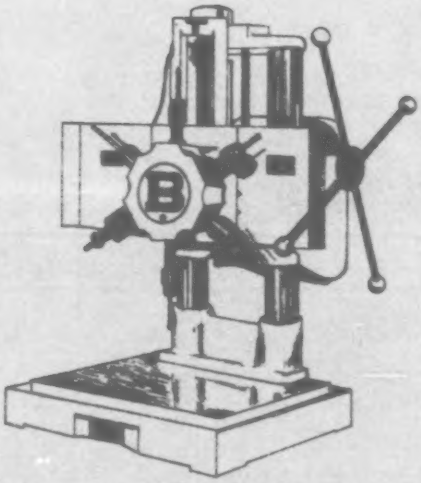
2. Identify types of drill presses seen in the following illustrations. Write the correct names in the blanks.

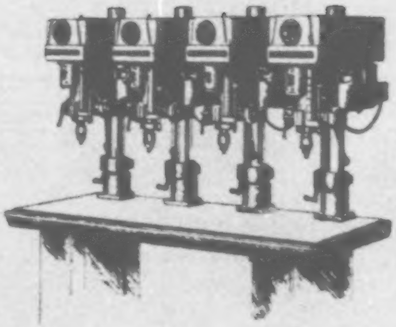
Sensitive bench drill press
Upright drill press
Radial arm drill press
Gang drill press
Multispindle drilling, boring, and tapping machine
Bench turret drill press
Numerical control turret drilling and tapping machine



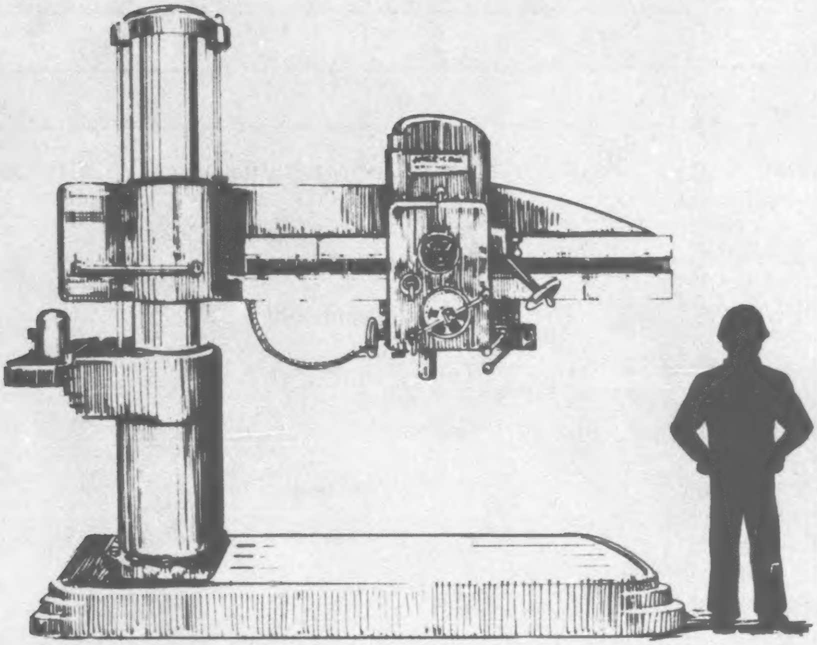


a. ____________________ b. ____________________

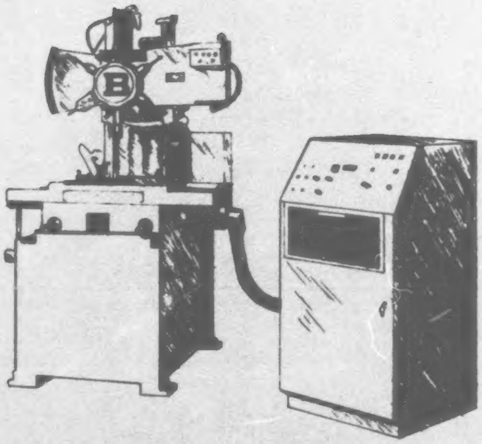


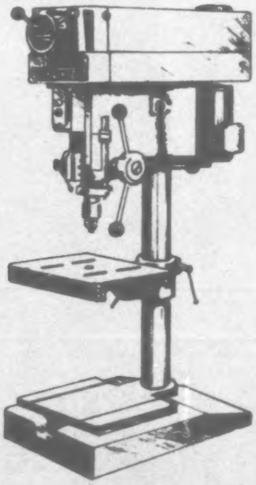


c. ____________________ d. ____________________



e. ____________________





f. ____________________ g. ____________________

3. Describe the function of a drill press-- ______________________________

____

____

____

4. Identify major parts of a drill press as seen on the next page. Write the correct numbers in the blanks.

Speed selector

Head

Switch

Spindle lock

Depth gage

Spindle

Coolant nozzle

Table

Table stop collar

Coolant pump

Table locking bolts

Table elevating crank

Column

Manual feed lever

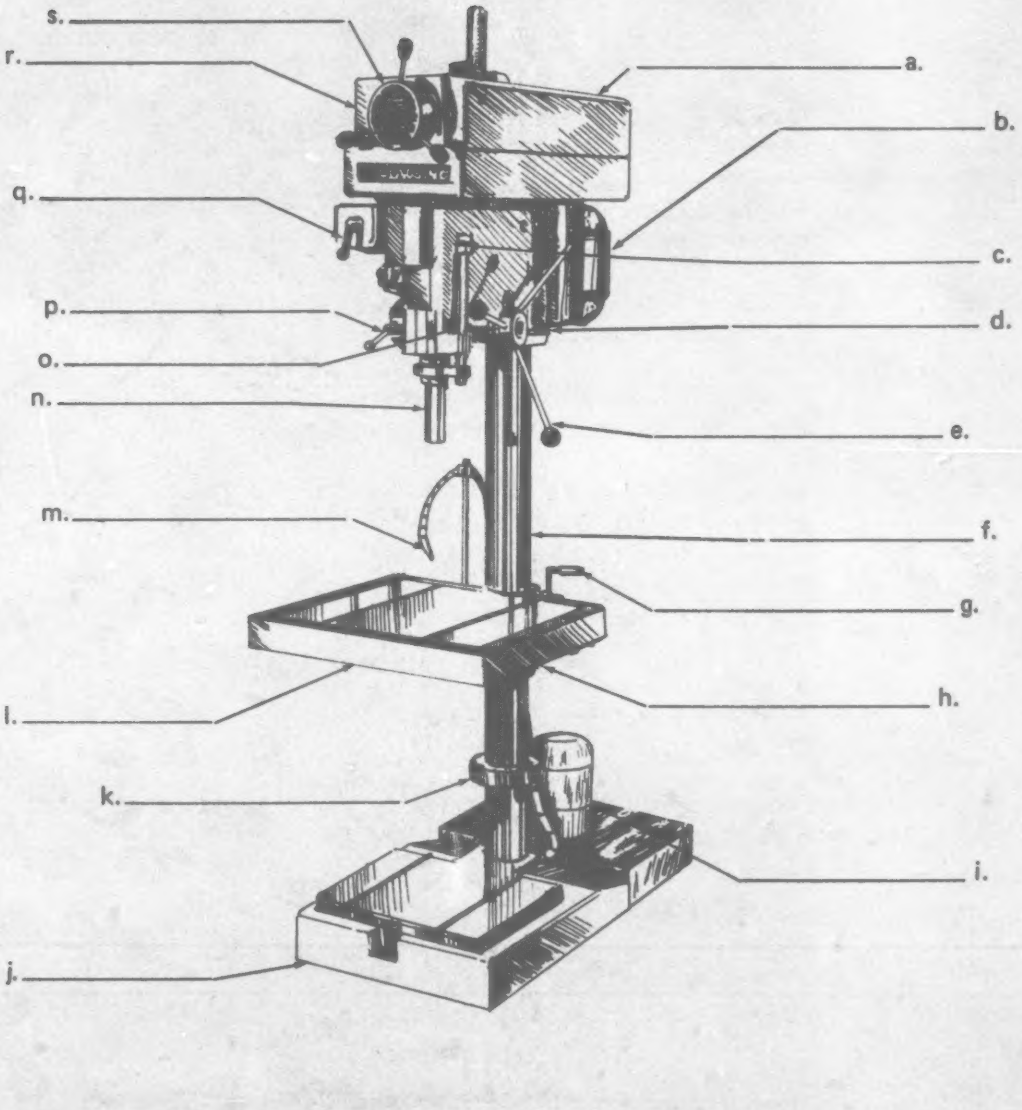
Feed drive

Motor

Belt guard

Base

Depth stop


s.
r.
a.
b.
q.
c.
p.
d.
o.
n.
e.
m.
f.
g.
l.
h.
k.
i.
j.

5. Match operations performed on a drill press to the correct definitions. Write the correct numbers in the blanks.

______a. Producing a screw thread in a hole that has been drilled to a specific size

______b. Producing a tapered surface in a hole so a flat head screw will be flush with the top surface of the part

______c. Producing a hole of a given size and depth

______d. Making a small angular surface at the top of a hole

______e. Making a flat surface so a bolt head or nut will seat properly

______f. Making a hole with a tapered top so the drill will start in location desired

______g. Producing a small hole that is used to guide a larger drill and reduce the feed pressure of the larger drill

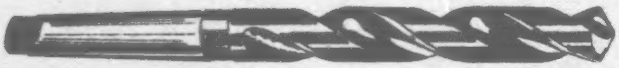
______h. Enlarging a hole with a flat bottom for a screw head to set in below the surface

______i. Enlarging a hole a small amount to make it true to size

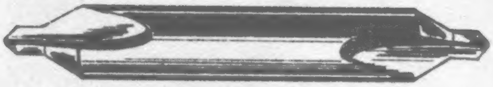
______j. Enlarging an existing hole to a given size and depth

1. Center drilling
2. Drilling
3. Boring
4. Counterboring
5. Countersinking
6. Tapping
7. Spot facing
8. Reaming
9. Chamfering
10. Drilling a pilot hole

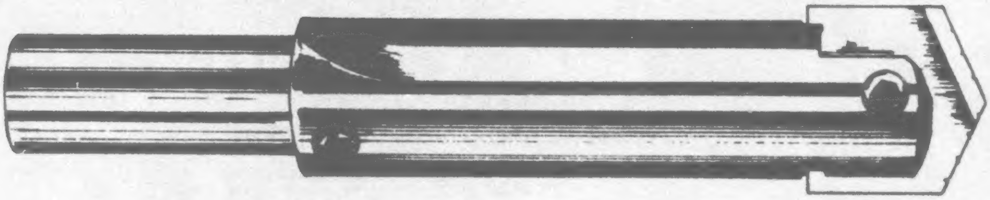
6. Name cutting tools used for drill press operations as seen in the following illustrations. Write the correct names in the blanks.



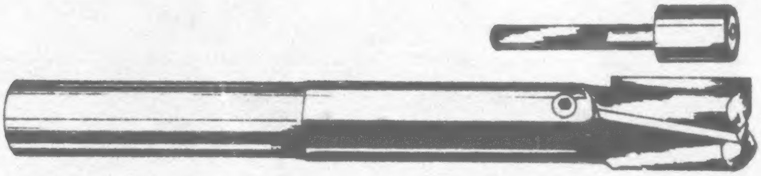
a. ______________________________



g. ______________________________



h. ______________________________



i. ______________________________

7. Describe types of drill press spindle drives.

   a. Cone pulley drive-- ______________________________

   ____

   ____

   b. Variable speed drive-- ______________________________

   ____

   ____

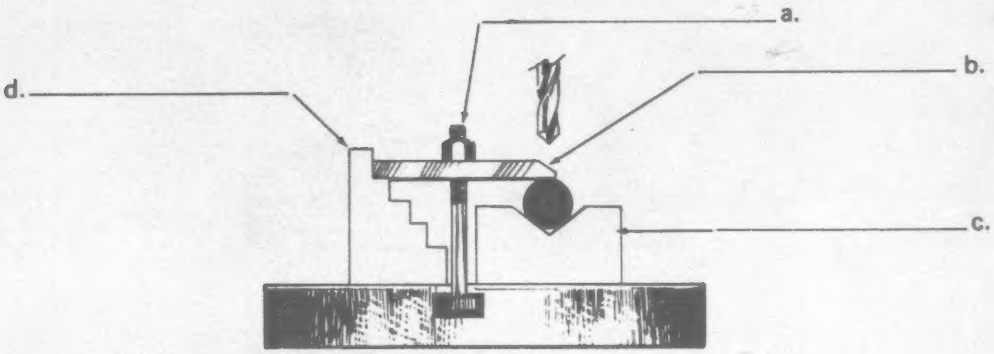
   c. Gear head drive-- ______________________________

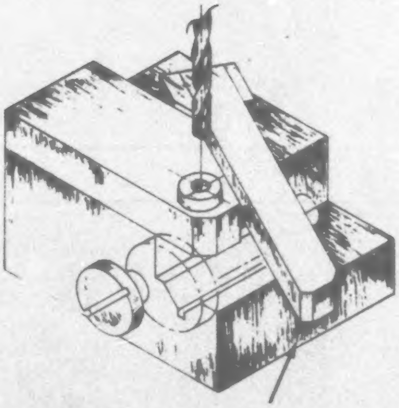
   ____

   ____

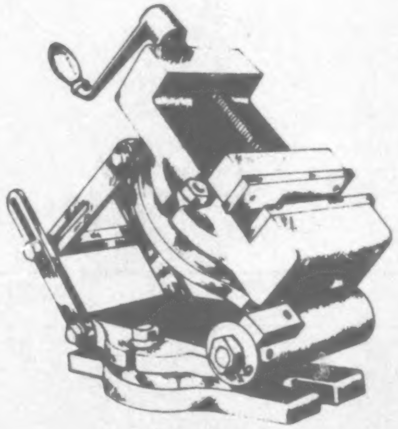
8. Identify workholding and set-up devices used in drill press operations as seen in the following illustrations. Write the correct names in the blanks.

Vise
Parallel clamp
C-clamp
Drill fixture
Step block
Strap clamp
Angle plate
V-block
Angle vise
T-bolt
Parallels
Screw jack

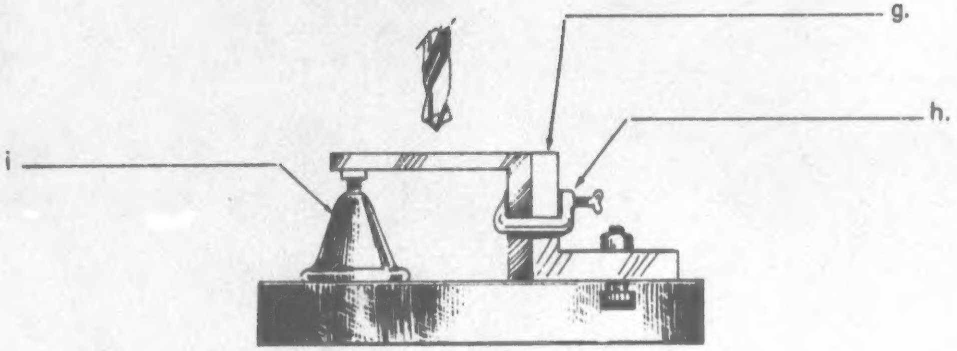


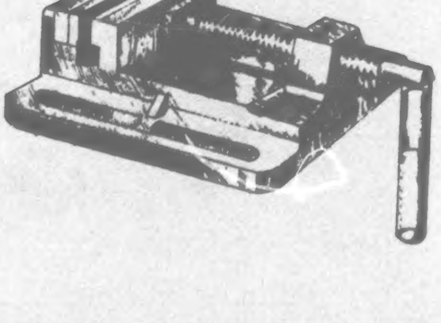


e. ______________________

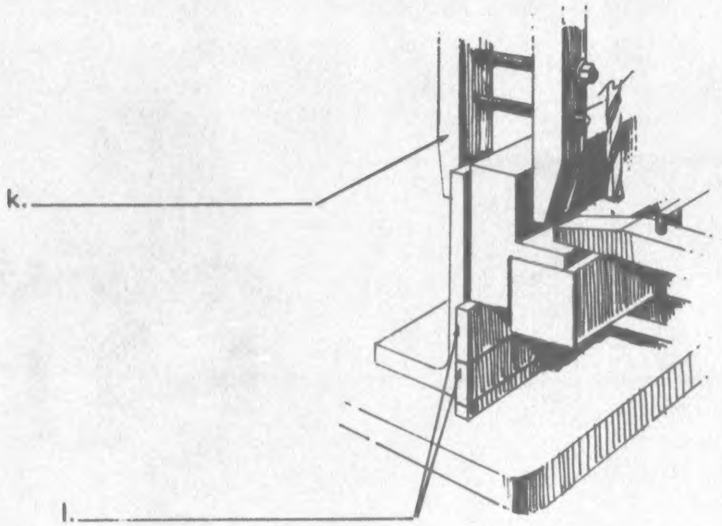


f. ______________________



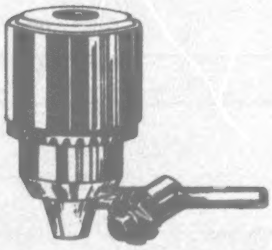


j. ______________________

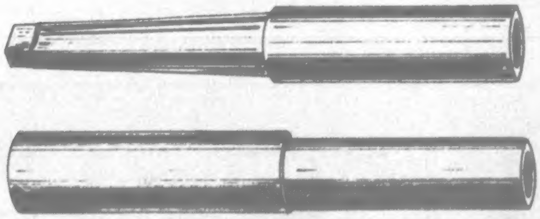


9. Identify attachments and accessories used with drill presses. Write the correct names in the blanks.

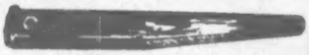
Tapping attachment
Floating chuck
Drill drift
Steel sockets
Drill chuck
Morse taper shank adapter sleeve



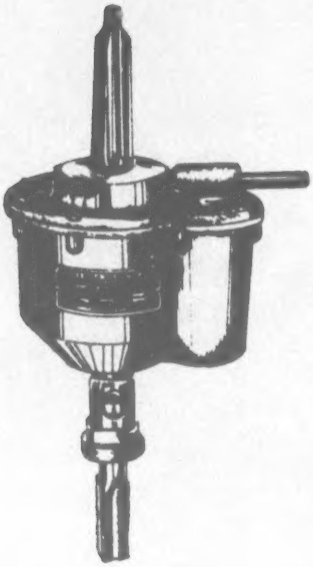
a. ______________________



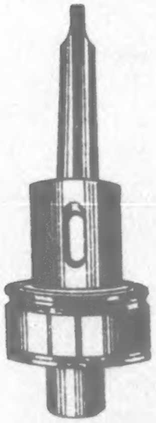
b. ______________________

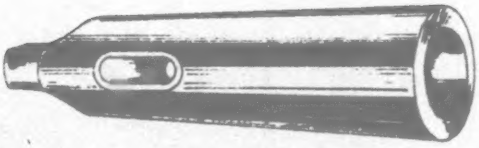


c. ____________________



d. ____________________





e. ____________________

f. ____________________

10. List three methods of applying coolants.

a. ____________________

b. ____________________

c. ____________________

11. State rules for safe use of drilling machines.

a. Eyes– ______________________________

____

b. Clothing– ______________________________

____

c. Guards– ______________________________

____

d. Chuck key or drill drift– ______________________________

____

____

e. Watches and rings– ______________________________

____

f. Chips– ______________________________

____

g. Rags– ______________________________

____

h. Work-- ______________________________

____

i. Feed pressure– ______________________________

____

j. Drill chuck-- ______________________________

____

k. Drill drift-- ______________________________

____

l. Machine in motion-- ______________________________

____

m. Hands– ______________________________

____

n. Table-- ______________________________
____

o. Spindle tapers-- ______________________________
____

p. Deep holes-- ______________________________
____

q. Chucks and other tools with tapered sharks-- ______________________________
____
____

r. Floor-- ______________________________
____

s. Drill press-- ______________________________
____

t. Tools-- ______________________________
____

u. Hair-- ______________________________
____

12. Discuss care and cleaning of drilling machines.

a. Lubrication-- ______________________________
____

b. Belts-- ______________________________
____

c. Variable speed drives-- ______________________________
____

d. Gear drives-- ______________________________
____

e. Chips-- ______________________________

f. Tools-- ______________________________
____

13. Select from the following list factors that affect cutting speeds for drilling operations. Mark each correct answer with an "X."

_____a. Kind of coolant

_____b. Rigidity of set-up

_____c. Drill size

_____d. Thickness of material

_____e. Type of material to be drilled

_____f. Type of drilling operation

_____g. Drill material

14. Determine rpm for drilling using the following drill speed chart. Write your answers in the blanks provided.

a. 1/2" drill, drilling holes in tool steel with a CS of 60 feet

answer____________rpm

b. 1" drill, drilling holes in 2" thick aluminum plate with a CS of 300

answer____________rpm

High Speed Steel Drills

Size of Drill	Feed per Rev.	Aluminum Plate, Bronze, Brass, 300 Feet	Cast Iron, Annealed, 170 Feet	Cast Iron, Hard, 80 Feet	Mild Steel 120 Feet	Drop Forg., 60 Feet	Mal. Iron, 90 Feet	Tool Steel, 60 Feet	Cast Steel, 40 Feet
Ins.	Ins.	rpm	rpm	rpm	rpm	rpm	rpm	rpm	rpm
1/16	0.003	....	....	4880	....	3660	....	3660	2440
1/8	0.004	....	5185	2440	3660	1830	2745	1830	1220
3/16	0.005	....	3456	1626	2440	1210	1830	1220	807
1/4	0.006	4575	2593	1220	1830	915	1375	915	610
5/16	0.007	3660	2074	976	1464	732	1138	732	490
3/8	0.008	3050	1728	813	1220	610	915	610	407
7/16	0.009	2614	1482	698	1046	522	784	522	348
1/2	0.010	2287	1296	610	915	458	636	458	305
5/8	0.011	1830	1037	488	732	366	569	366	245
3/4	0.012	1525	864	407	610	305	458	305	203
7/8	0.013	1307	741	349	523	261	392	261	174
1	0.014	1143	648	305	458	229	349	229	153
1 1/4	0.016	915	519	244	366	183	275	183	122
1 1/2	0.016	762	432	204	305	153	212	153	102
1 3/4	0.016	654	371	175	262	131	196	131	87
2	0.016	571	323	153	229	115	172	115	77

15. Calculate drill speeds using rpm formula for the following drilling operations. Show your work, and write your answers in the blanks provided.

(NOTE: All drills are H.S.S.)

a. You are to drill 5 holes 1/2" in diameter in a mild steel plate with a CS of 100" per minute. How many rpms should the drill turn? ____________________

b. If you are using a drill press with a step pulley drive having speeds of 240,380, 600, 900, and 1500 rpm, what speed would you use for problem 15a? ________

c. You are to drill five 5/16" diameter and two 3/4" diameter holes in a tempered aluminum plate 1 1/2" thick. The CS for the aluminum is 250 feet per minute. How many rpms should the two drills turn?

1. 5/16" drill __________________
2. 3/4" drill ____________________

16. Demonstrate the ability to:

a. Drill and ream holes to layout.

b. Countersink and counterbore holes to specification.

c. Tap holes using the drill press.

(NOTE: If the above activities have not been finished before the test, ask your instructor when they should be completed.)

DRILL PRESS
UNIT II

ANSWERS TO TEST

(NOTE: The point system designated in parentheses is intended to be a guideline and should be adapted as needed. The point total is 350.)

1. (20 points)

   a. 3
   b. 5
   c. 10
   d. 7
   e. 4
   f. 9
   g. 1
   h. 6
   i. 2
   j. 8

2. (14 points)

   a. Multispindle drilling, boring, and tapping machine
   b. Upright drill press
   c. Bench turret drill press
   d. Gang drill press
   e. Radial arm drill press
   f. Numerical control turret drilling and tapping machine
   g. Sensitive bench drill press

3. (4 points)

   To produce round holes in material by using twist drills and other types of cutting tools

4. (38 points)

   a. Belt guard
   b. Motor
   c. Depth stop
   d. Feed drive
   e. Manual feed lever
   f. Column
   g. Table elevating crank
   h. Table locking bolts
   i. Coolant pump
   j. Base
   k. Table stop collar
   l. Table
   m. Coolant nozzle
   n. Spindle

o. Depth gage
p. Spindle lock
q. Switch
r. Head
s. Speed selector

5. (20 points)

a. 6
b. 5
c. 2
d. 9
e. 7
f. 1
g. 10
h. 4
i. 8
j. 3

6. (18 points)

a. Tapered shank twist drill
b. Straight shank twist drill
c. Tap
d. Tapered shank reamer
e. Straight shank reamer
f. Countersink
g. Center drill (combination drill and countersink)
h. Spade drill
i. Counterbore or spot facer with pilot

7. (9 points)

Description should include:

a. Cone pulley drive--Found on most sensitive type bench and floor mounted machines; speeds are obtained by changing belt position

b. Variable speed drive--Found on sensitive type floor mounted machines; speeds are obtained by turning the speed selector

c. Gear head drive--Found on floor mounted machines like box column and radial drill presses; speeds are obtained by changing gears

8. (24 points)

a. T-bolt
b. Strap clamp
c. V-block
d. Step block
e. Drill fixture
f. Angle vise
g. Angle plate
h. C-clamp
i. Screw jack
j. Vise
k. Parallel clamp
l. Parallels

9. (12 points)
   a. Drill chuck
   b. Steel sockets
   c. Drill drift
   d. Tapping attachment
   e. Floating chuck
   f. Morse taper shank adapter sleeve

10. (9 points)

    Any three of the following:

    a. Oil can
    b. Spray mist
    c. Flood
    d. Brush

11. (63 points)
    a. Eyes--Always wear safety glasses to protect your eyes from chips
    b. Clothing--Always wear tight-fitting clothes to prevent them from being caught in revolving parts
    c. Guards--Never operate the drilling machine with guards removed
    d. Chuck key or drill drift--Should be removed immediately after using; never leave key in drill chuck or drift in spindle because if machine is turned on they will be thrown and possibly cause injury
    e. Watches and rings--Remove before operating drill press or any machine to prevent possible accidents
    f. Chips--Remove with a brush, never your hands
    g. Rags--Should never be used while machine is running, and never left on the table of a running machine
    h. Work--Should always be held in a vise or other workholding device that is secured to the table; never try to hold work with your hands
    i. Feed pressure--Ease up when the drill is breaking through so it will not grab and leave a big burr
    j. Drill chuck--Designed to hold straight shank drills and tools; should never be used to hold tools with tapered shanks
    k. Drill drift--The only tool that should be used to remove tapered shank tools from spindles or sleeves

l. Machine in motion--Never clean or make adjustments while machine is running

m. Hands--Never pick up a drill, work, or any tool that you have been using as it is hot and will burn; use a rag

n. Table--Should be kept clean and free of tools to eliminate accidents and possible damage to tools

o. Spindle tapers--Should never be cleaned when spindle is being turned by power

p. Deep holes--Interrupt the feed occasionally to break up chips and clear the drill

q. Chucks and other tools with tapered shanks--Always place a board on the table under tool so when you break the taper with the drill drift it will not fall and damage the tool or table of the drill press

r. Floor--Keep work area clean and free of slippery materials or chips to prevent accidents

s. Drill press--Clean machine and floor after using drill press

t. Tools--Clean oil or coolant from drills and other tools and put them up in the proper place

u. Hair--Long hair must be secured under a hat, in a hair net, or tied back to prevent it from being caught by rotating parts of the drill press

12. (12 points)

a. Lubrication--Check all oil levels for proper levels before using

b. Belts--Check drive belts for proper tightness

c. Variable speed drives--Never crank the speed selector when spindle is not turning

d. Gear drives--Never shift gears when spindle is turning; shut off machine

e. Chips--Clean chips off table with a brush

f. Tools--Never use a dull tool since it causes more friction and will ruin the tool

13. (14 points)

c, e, g

14. (8 points)

a. 458

b. 1143

15. (20 points)

a. $\frac{4 \times 100}{.5} = 800$ rpm

b. 900

c. 1) $\frac{4 \times 250}{.312} = 3205$

2) $\frac{4 \times 250}{.75} = 1333$ rpm

16. (65 points) Performance skills evaluated to satisfaction of instructor